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Swift
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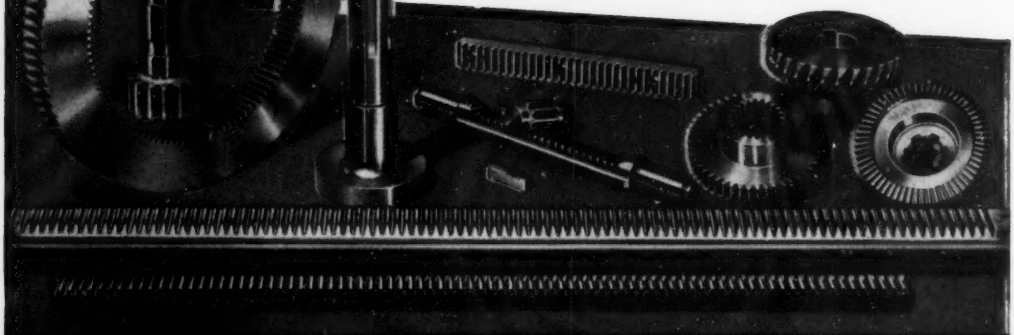

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- NEW
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Can be used on standard types of Cutter Grinders, Cylindrical Grinders, or Lathes fitted with toolpost grinding attachments.

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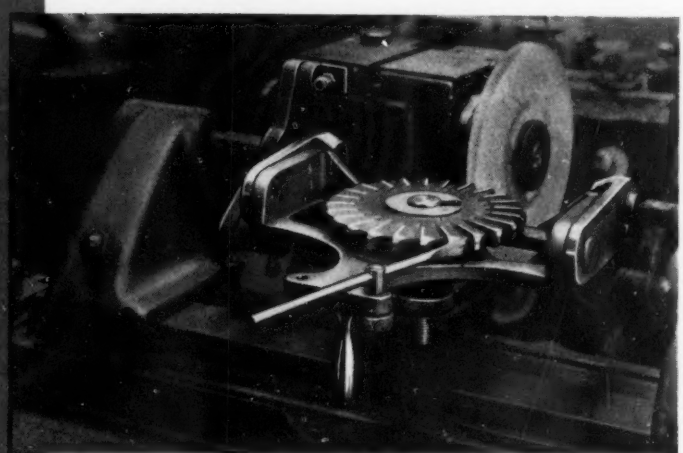
Cutters 3in. to 8in. dia., 1¼in. wide
Radii ... ... Up to ¼in.

Full particulars on application

RADIUS GRINDING ATTACHMENT FOR MILLING CUTTERS *(Patent applied for)*



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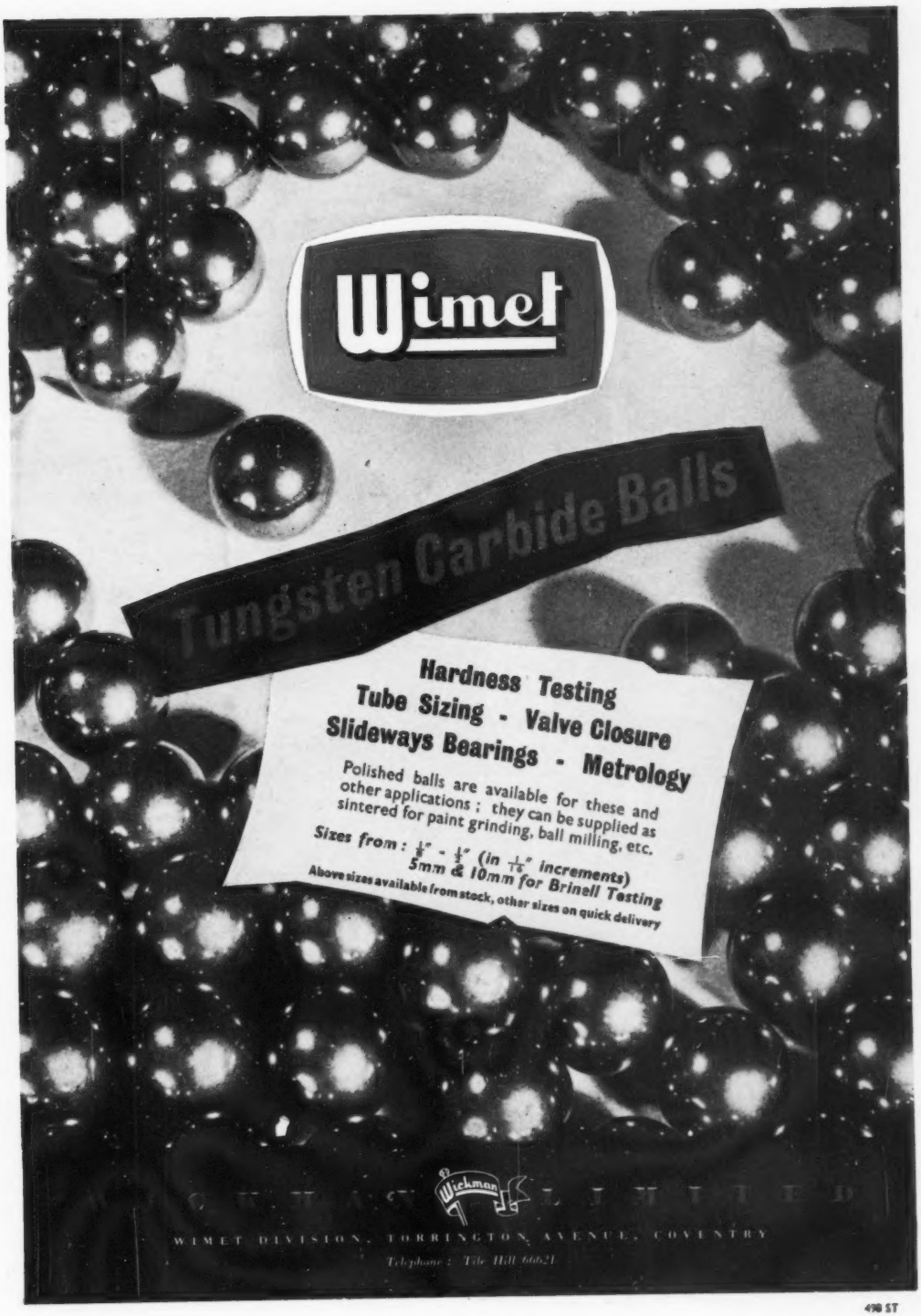
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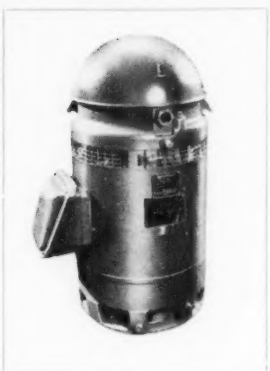
Inspire Newman design when special conditions have to be met, as with the range of vertical solid and hollow shaft pump motors. A special survey was taken of the pumping industry and of the conditions under which such motors were required to operate before the designs were finalised. Now Newman Vertical Solid and Hollow Shaft Pump Motors lead the field in fitness-for-purpose and are securing contracts against world-wide competition.



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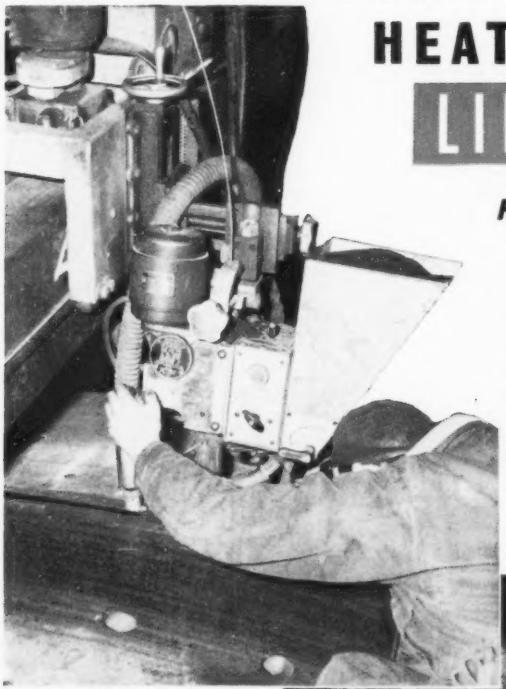

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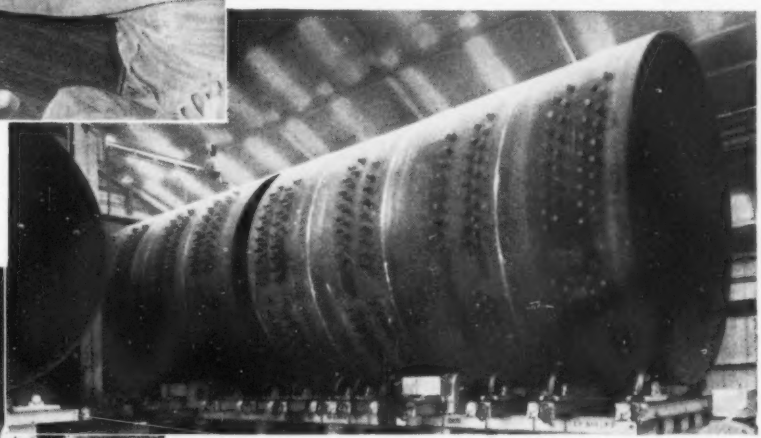
LINCOLNWELDED

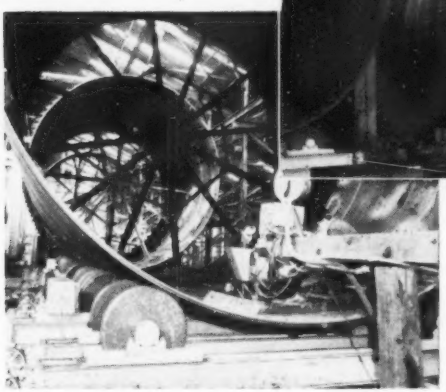
For Bradwell Nuclear Power Station, Essex

The 12 heat exchangers for Bradwell Nuclear Power Station, Essex, each weighing 200 tons are being designed and fabricated by Head Wrightson & Co. Ltd., a member of the Nuclear Power Plant Company Limited, using 10 LINCOLNWELD Fully Automatic submerged-arc welding units.

The vessels are subject to the requirements of Lloyd's Class 1 Standards for fusion welded pressure vessels, and all the welds are radiographically examined, and finally stress-relieved.

The above photograph shows a close up view of a LINCOLNWELD Fully Automatic submerged-arc welding unit, working on an external weld.





The photographs show *(Above)* the completed shell of the first exchanger. *(Left)* an internal weld being made with a LINCOLNWELD Fully Automatic submerged-arc welding unit.

LINCOLN's wide experience gained from installing hundreds of Automatic Units throughout the world is at your SERVICE.

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WHEREVER ACCURACY

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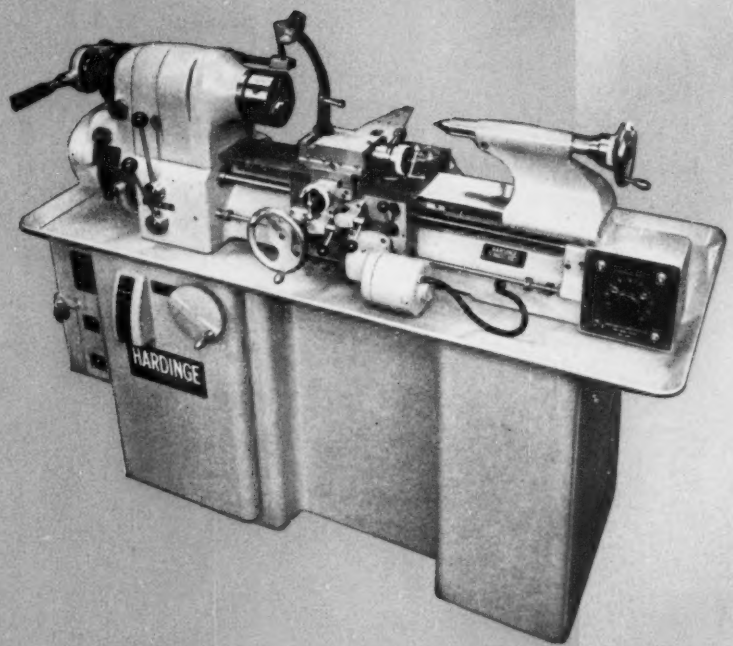

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(One of the Sheepbridge Group)

Feltham · Middlesex · England

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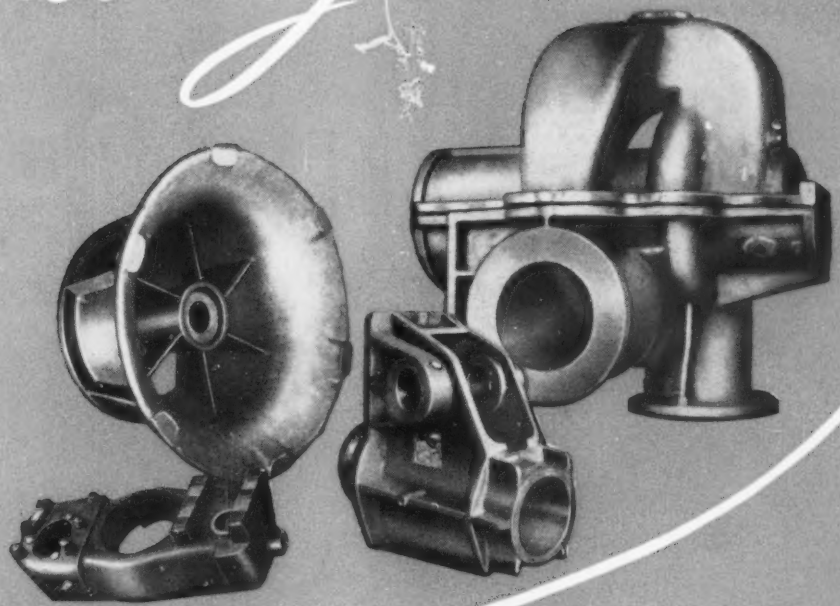

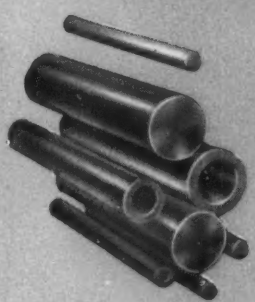

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Working under ideal conditions, skilled machinists achieve **CONSISTENCY** all along the production line.

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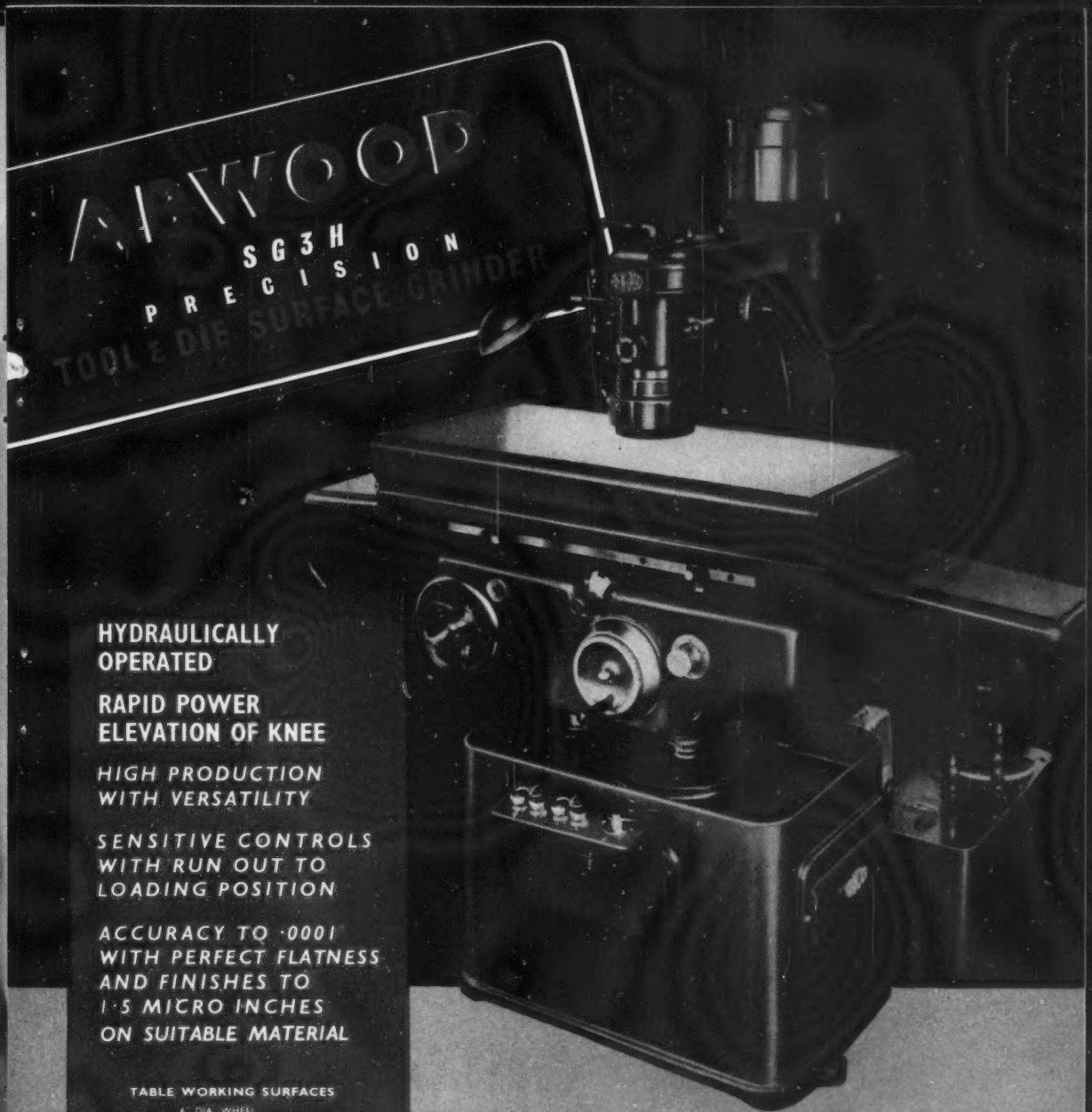

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ACCURACY TO ·0001 WITH PERFECT FLATNESS AND FINISHES TO 1·5 MICRO INCHES ON SUITABLE MATERIAL

TABLE WORKING SURFACES

10½" UNDER WHEEL

This latest development model SG3H is "the" Machine for rapid Surfacing in the Toolroom or Production Shop.
Detachable Spindles are available for deep and intricate work.

Hydraulic Control allows the operator to "inch" the Table along or stop instantaneously in any position at will.

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SG-1

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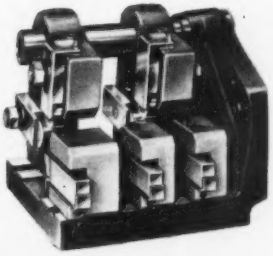

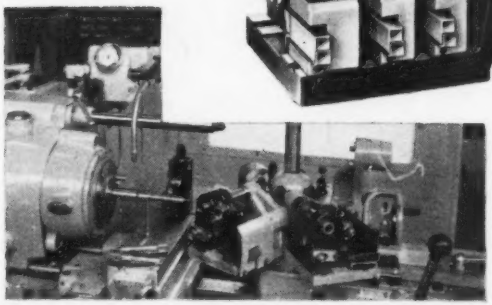

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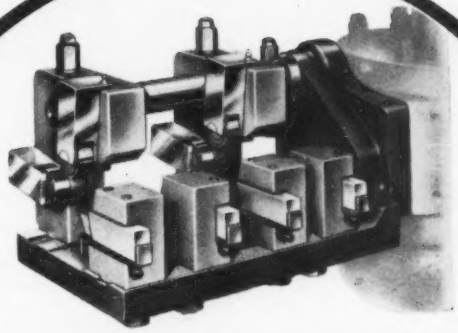
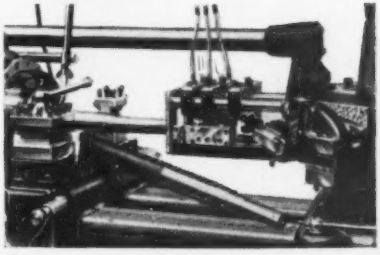
Multiple Roller Turning Toolholders

Constructed for turning one, two, three or more diameters with tungsten-carbide tools, these holders present the tools to the work in quickly set robust slides having independent adjustment. The roller holders are interchangeable and can be locked in any position along the body.





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3NP Plain Miller

Table
70 in. × 16¼ in.

Table Movements
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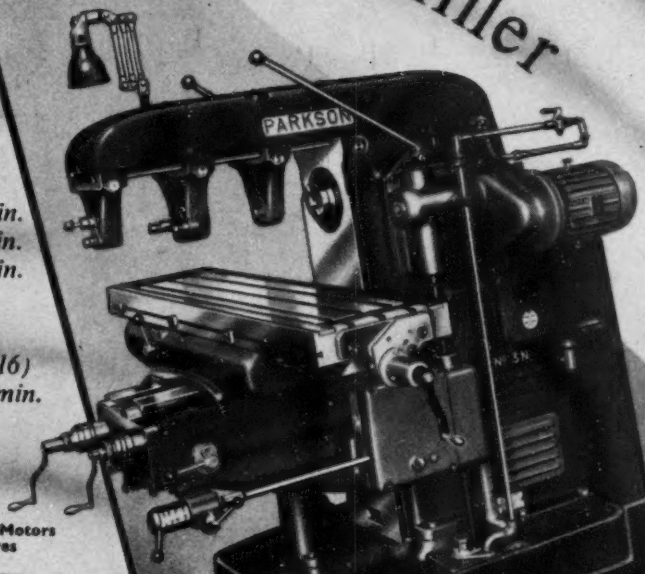
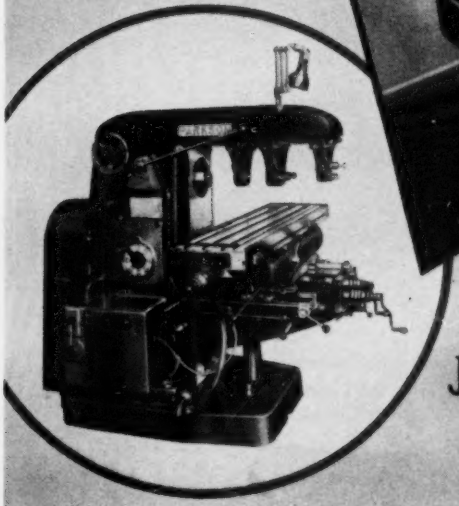
Cross 12 in.
Vertical 18 in.

Spindle speeds (16)
29 to 775 revs/min.

Supplied with Separate Motors for Speed and Feed Drives





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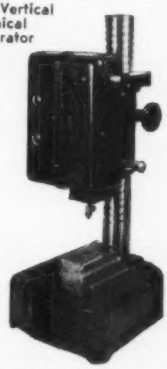
Sigma Vertical Mechanical Comparator



Sigma Junior Comparator

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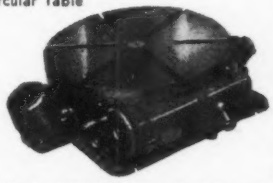
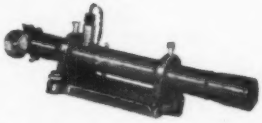
Watts Universal Microscope

Hilger Angle Dekkor

Matrix Optical Circular Table



Watts Microptic Auto-collimator



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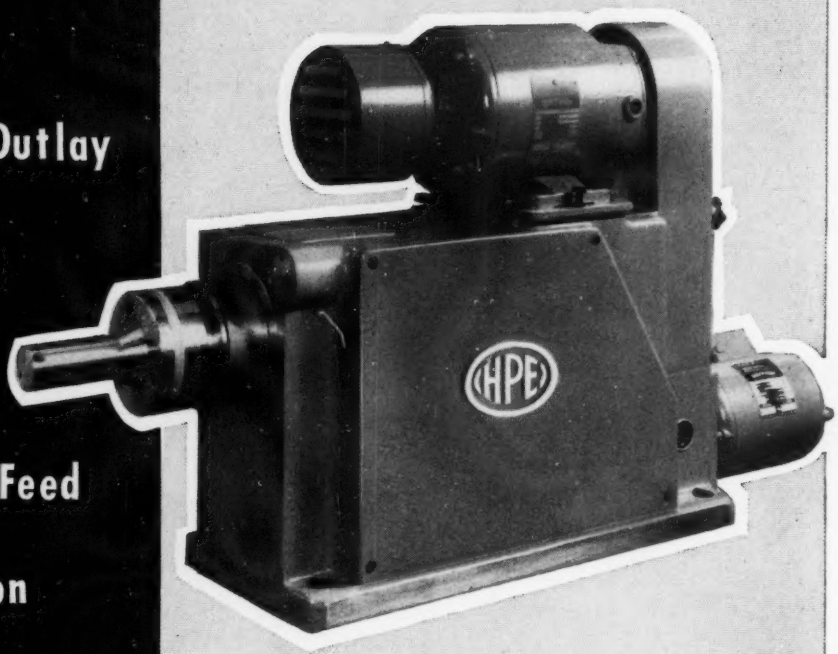

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Particularly suitable for mounting on simple base plates together with the necessary work holding fixture enabling single purpose units to be constructed for the minimum of time and cost. Wide range of speeds and feeds obtainable by changing feed cam and motor pulley.

"Descriptive brochure on request."

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High Precision Equipment Ltd

DESIGNERS AND MANUFACTURERS OF SPECIAL MACHINE TOOLS

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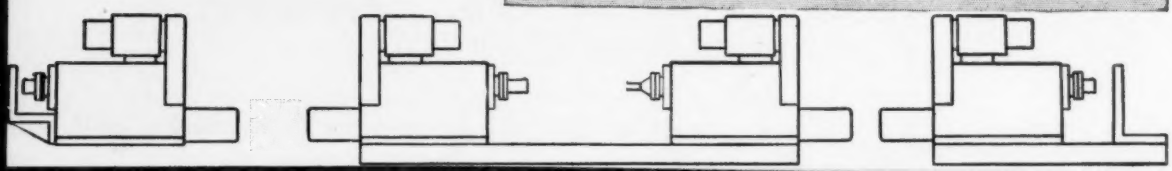

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FOR UNUSUAL MACHINES

MINUTES SLASHED TO SECONDS . . .

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MARBAIX

M58 DISINTEGRATOR

● REMOVES BROKEN TOOLS WITHOUT DAMAGE TO THE COMPONENT

● CUTS HOLES OF ANY SHAPE IN HARDENED MATERIAL, CARBIDES ETC.

. . . in fact any material through which electric current can pass.

The new MARBAIX M.58 disintegrator removes broken taps, drills, reamers, studs, etc., in a fraction of normal time, without damage to the component.

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HERE'S HOW TO CUT COSTS

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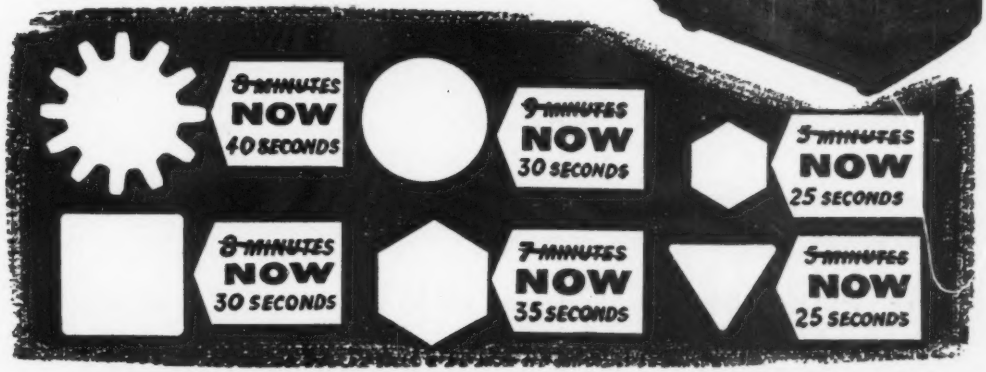
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WOTAN	ELB	SCHMALTZ
Large Swing Internal Grinders	Horizontal Spindle Surface Grinders	Rotary Table Surface Grinders

and a wide selection of "Soag Rebuilt" grinding machines by Churchill, Cincinnati, Newall, Norton, Snow, etc.

This visit to our Battersea Showrooms will be very well worth your while!

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These leaflets cover our complete range of Milling and Drilling Machines and give full technical data and specifications.

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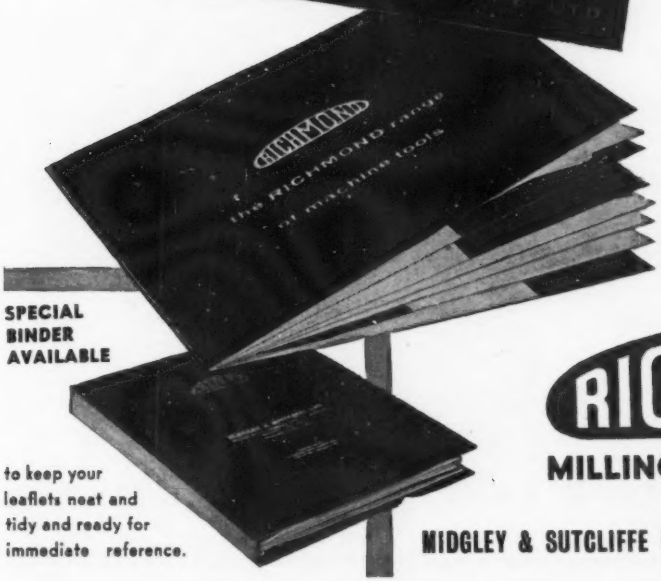

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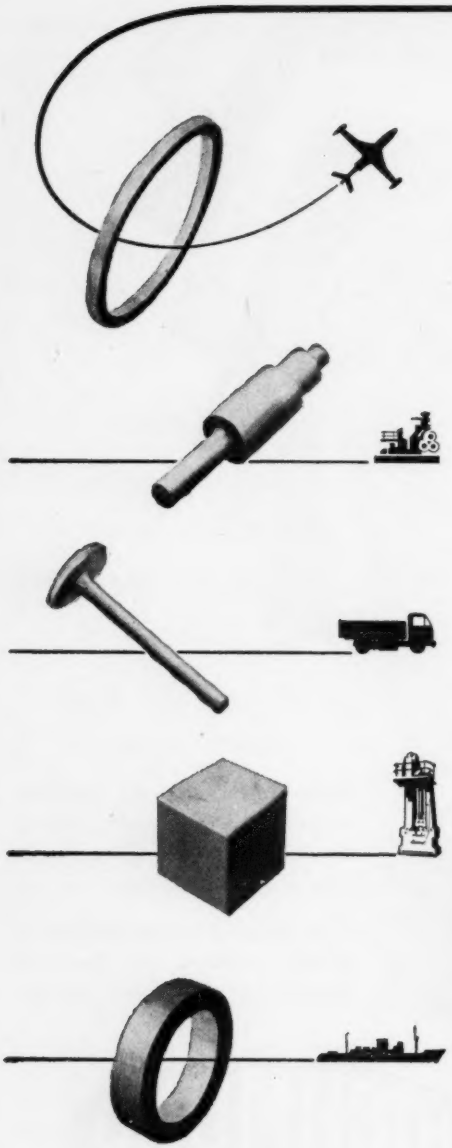

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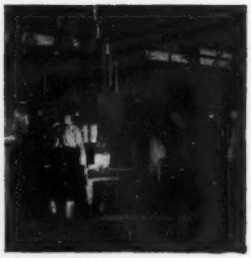
DONCASTERS ◇ *1778* D D



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FORGINGS · DROP FORGINGS · TOOL STEELS · HARDENED STEEL ROLLS

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A Proved JIG BORER

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THE MODEL VL600 aba

Optics by Leitz
Power Feed to Spindle
Covered ways

Large Selection of Extra Equipment Available

Brief Specification

Area of table	16" x 26"
Longitudinal Travel of table	26"
Cross Travel of table	17"
Number of spindle speeds, geometric progression ratio 1.41 ...	12
Spindle Speeds	31–1500 r.p.m.
8 Power feeds	·0015"–·017" p. rev.

12 page Booklet will be sent on application to Sole Agent!

ROCKWELL
MACHINE TOOL CO. LTD.

WELSH HARP, EDGWARE ROAD, LONDON, N.W.2. TELEPHONE: GLADSTONE 0033

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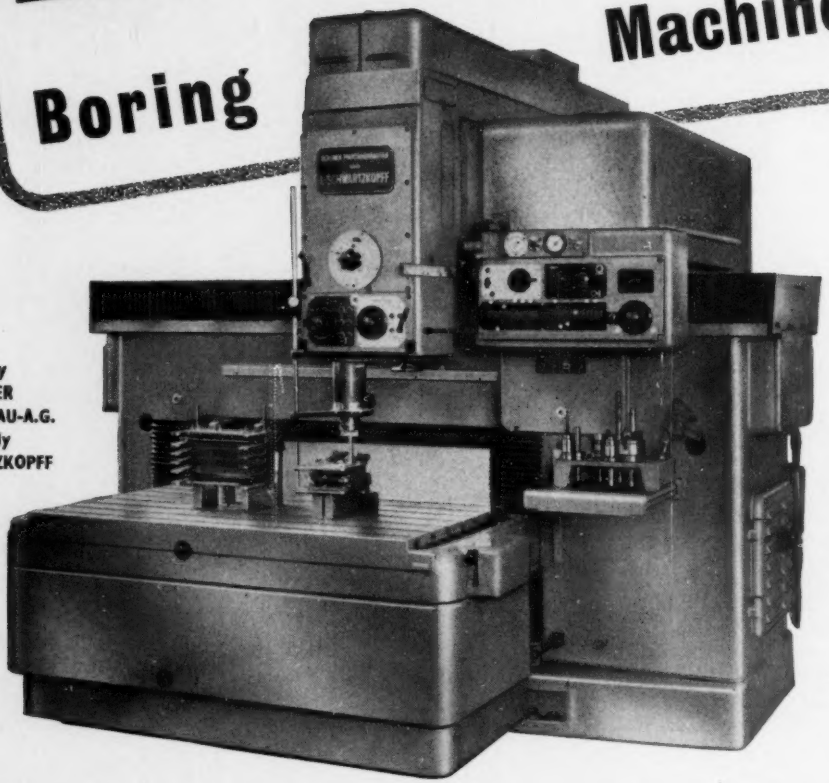
MOST FIRMS CHOOSE–

BEMAG

Punched card control

Boring Machines



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There are more BEMAG punched card controlled, automatic positioning Boring Machines in use in this country than any other make. The BEMAG Production Boring and Milling Machine for JIGLESS Production represents a revolutionary approach to single, batch and mass production Boring and incorporates automatic pre-selection of co-ordinate settings as well as feeds and speeds.

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Grinds Spiral Cutters and Clearance Angles by DIRECT SETTING

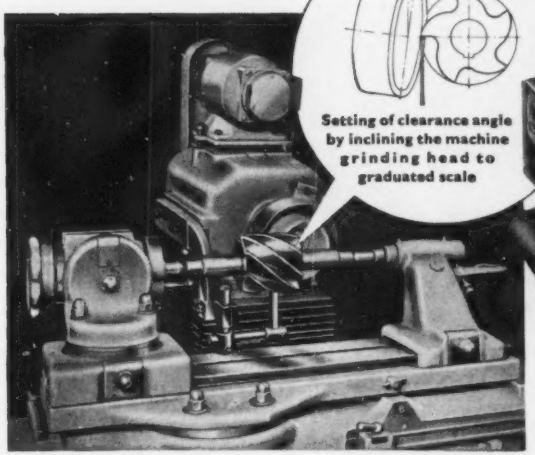
SCHÜTTE TOOL and CUTTER GRINDING MACHINE

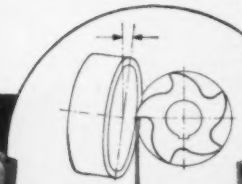
Head Swivels and TILTS

Grinding Spindle runs in Ball Bearings

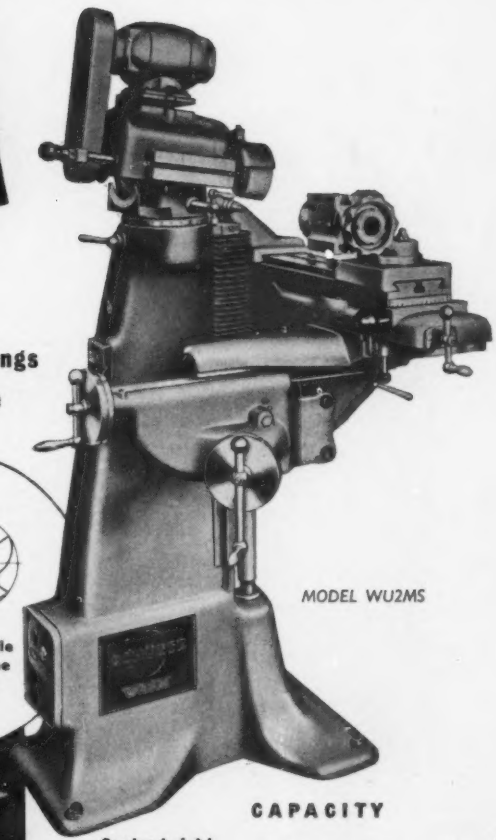
Precision Ball Bearing Track Table

Sensitive Table Movement





Setting of clearance angle by inclining the machine grinding head to graduated scale



MODEL WU2MS

CAPACITY

Centre height	4½"
Grinding diameter	Max. 10"
Centre distance=grinding length	12½"
Helix angle adjustment (right and left hand)	60°-0°-60°
Clearance angle inclinability ...	12°-0°-12°
2 Grinding Spindle Speeds	appr. RPM 3000/6000

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Note depth measuring device, automatically stopping machine when required depth has been reached.

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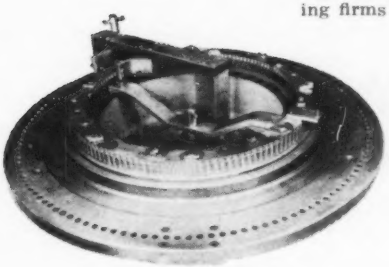

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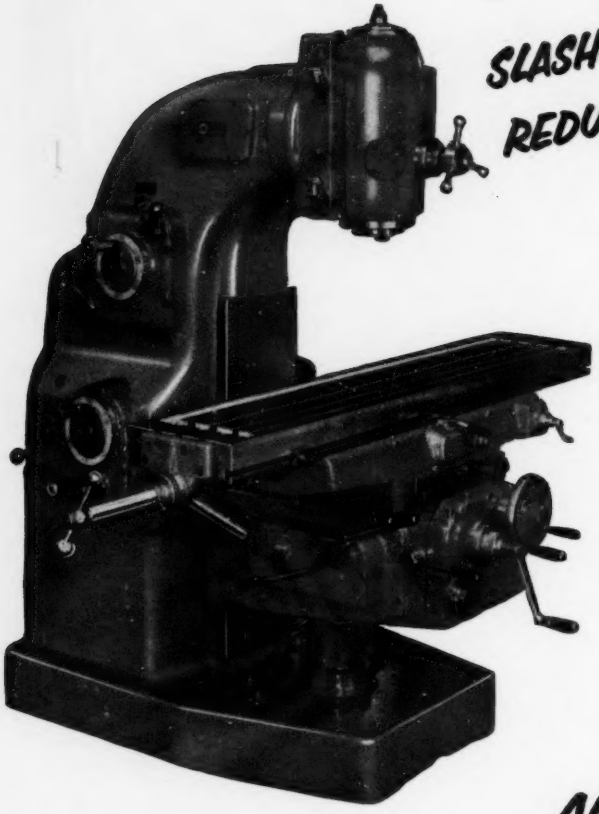

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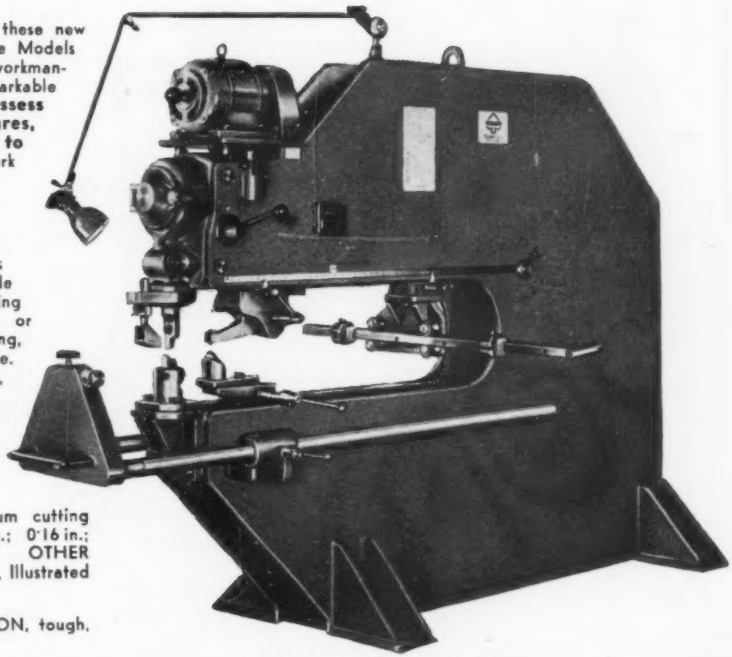

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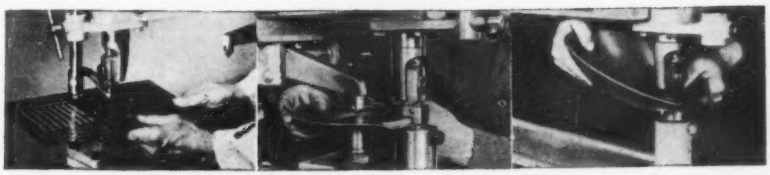

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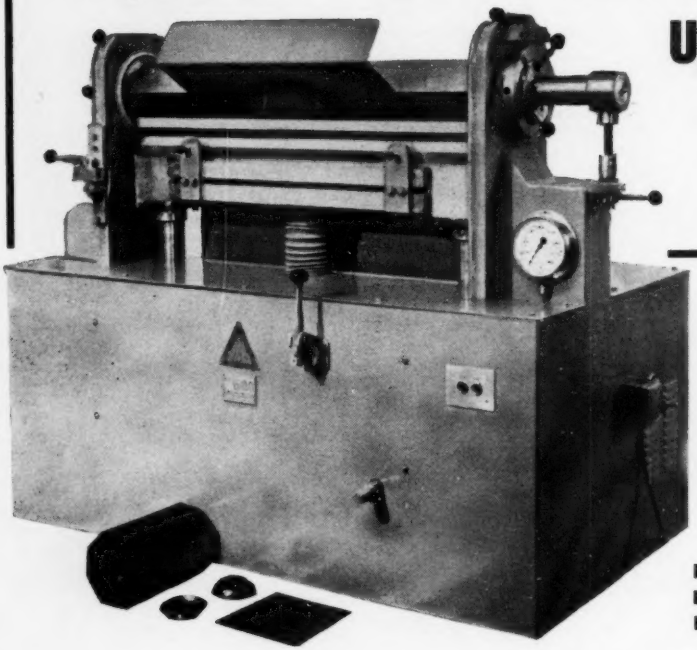

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- REMARKABLE EASE OF OPERATION.

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Table Travel Cross	12½"
Spindle Nose to Table	23⅜"
Sliding Head Travel	19 11/16"
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Spindle speed - R.P.M.	70-1300
Spindle Feeds	4
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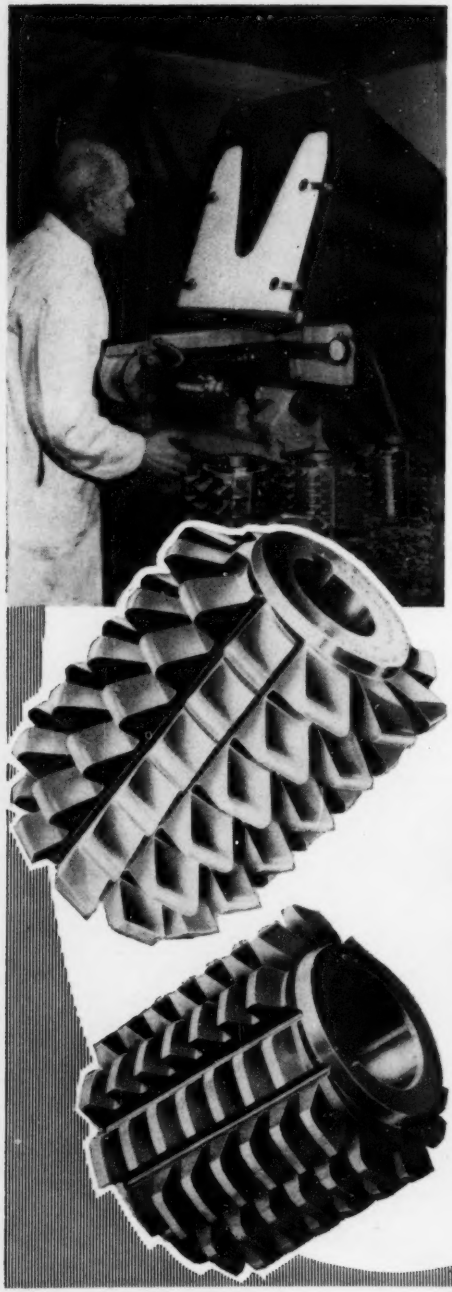

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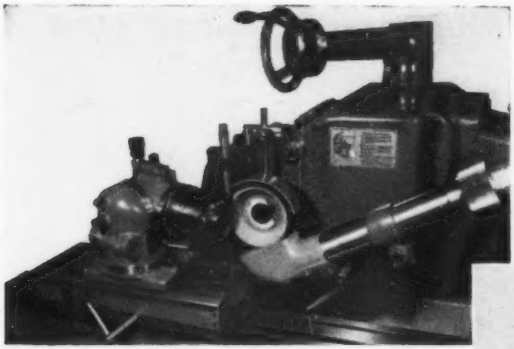
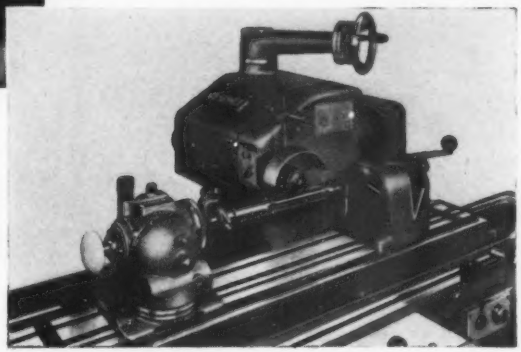


precision grinding with ---



The ideal machine for* FACE, CYLINDRICAL, INTERNAL SURFACE, TOOL AND CUTTER *grinding.

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universal grinders

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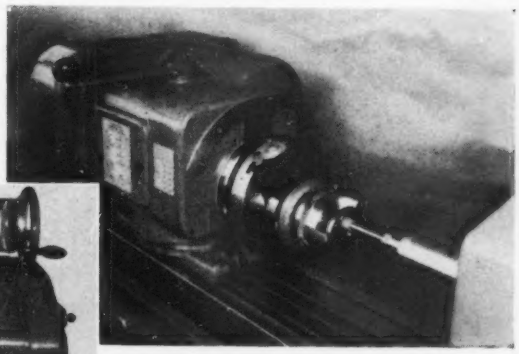

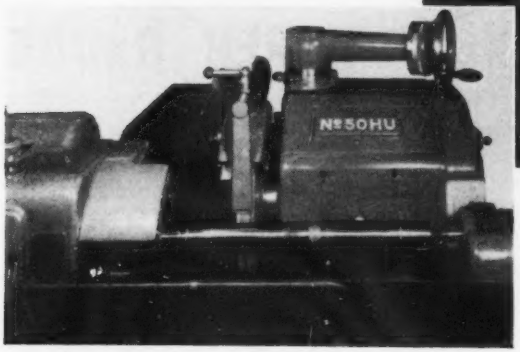

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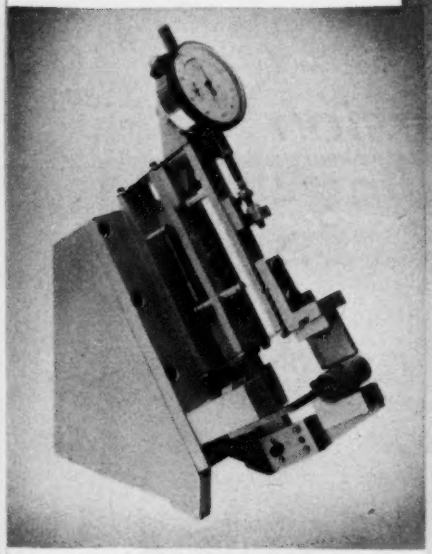
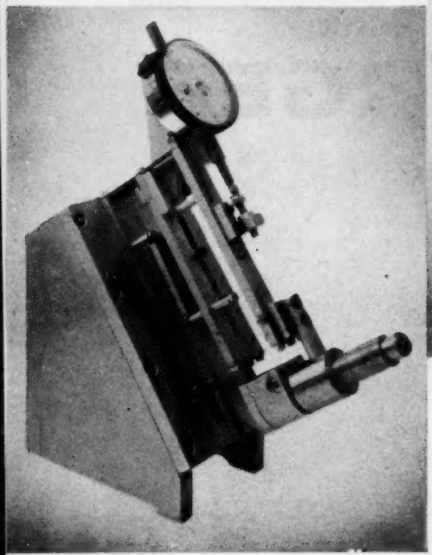
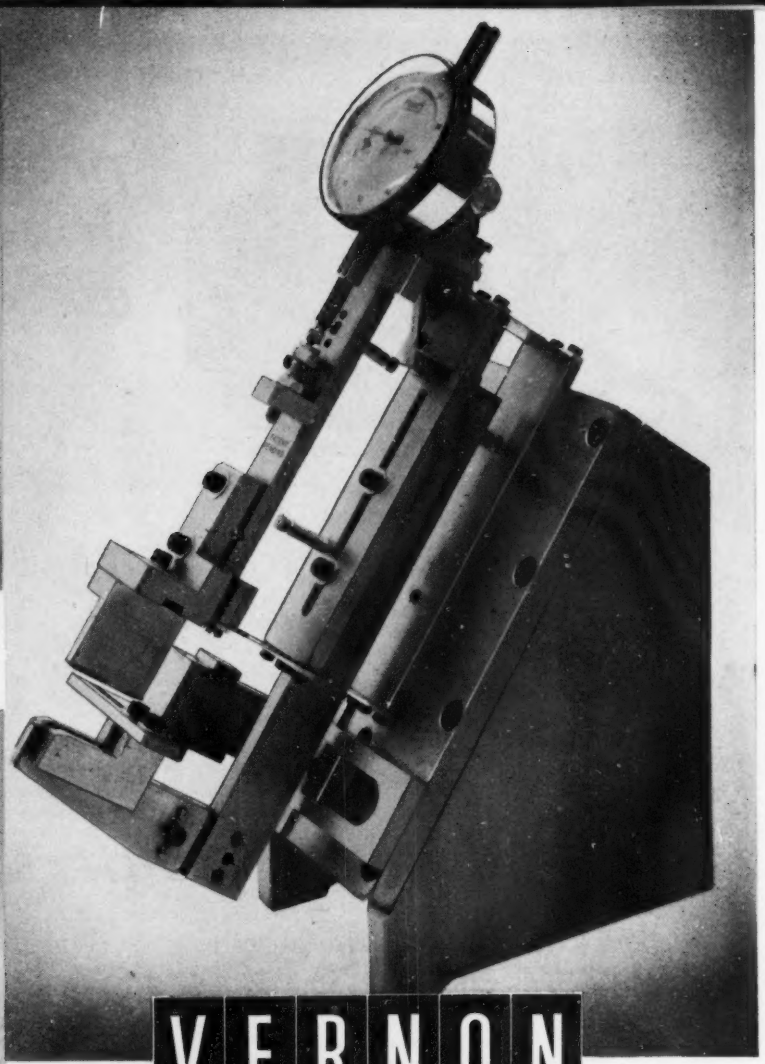


Basic unit arranged to measure outside diameters (above)

Basic unit arranged to measure bore diameter (below)





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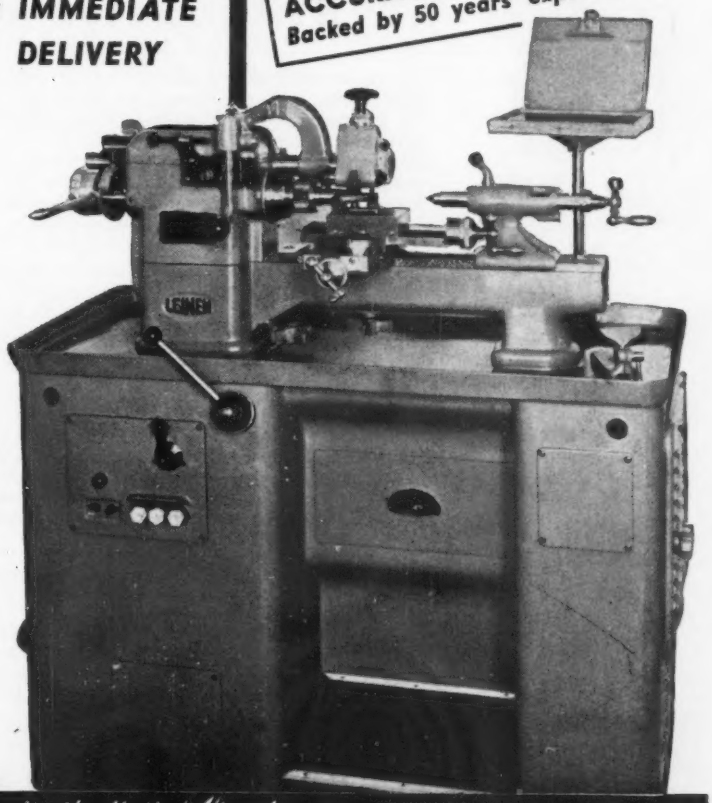

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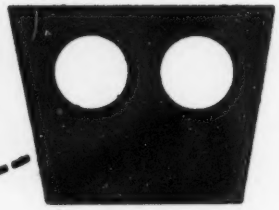

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- Five spindle speeds—110-1780 r.p.m. or 70-1180 r.p.m., alternatively 10 speeds 70-1780 r.p.m.
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MODELS RI 133 AND RI 134

WOTAN

HYDRAULIC FEEDS

AUTOMATIC CHANGE FROM ROUGHING TO FINISHING

SWIVELLING WORKHEAD

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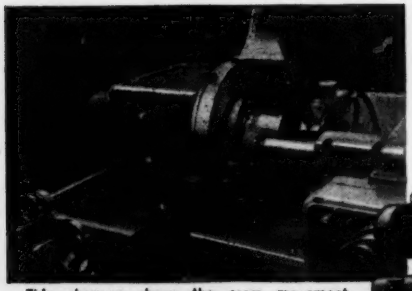
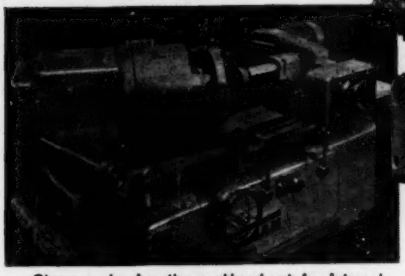
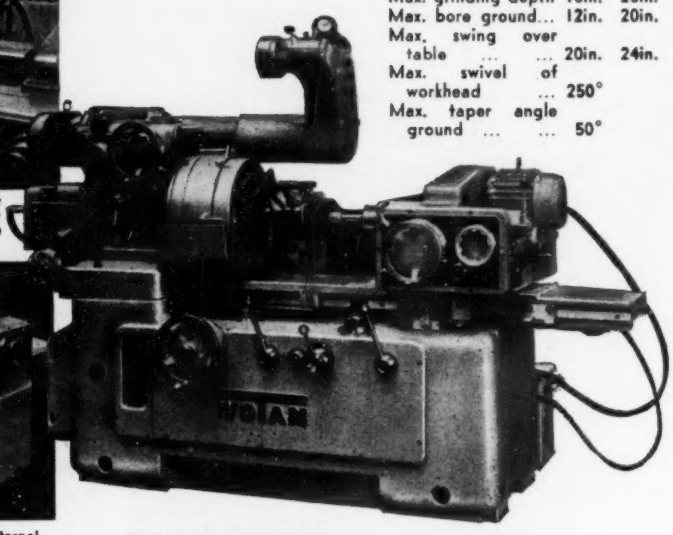
Max. grinding depth	10in.	20in.
Max. bore ground...	12in.	20in.
Max. swing over table	20in.	24in.
Max. swivel of workhead ...	250°	
Max. taper angle ground	50°	



This close-up shows the cross movement of the workhead, with the head set over for grinding the outside diameter of a large workpiece.



Close-up showing the workhead set for internal steep taper grinding.



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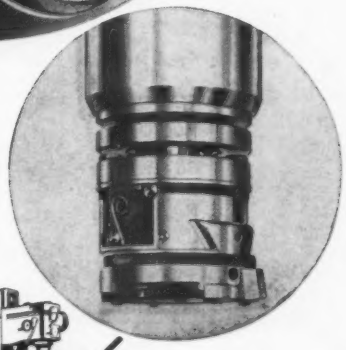
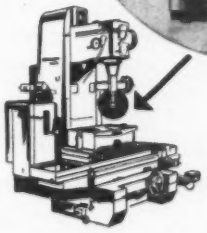
A hand wheel with finely graduated ring gives precise control of the boring bar diameter adjustment while the machine is actually in operation. Patented spindle bearings ensure perfect rigidity at maximum boring depth and tolerances of .00012" can easily be held.



Brief Specification

Spindle stroke	39¾"
Height under boring head	60"
Spindle to column	17¾"
Boring range	7/16" to 20 7/16"
Table size	18" x 47½"



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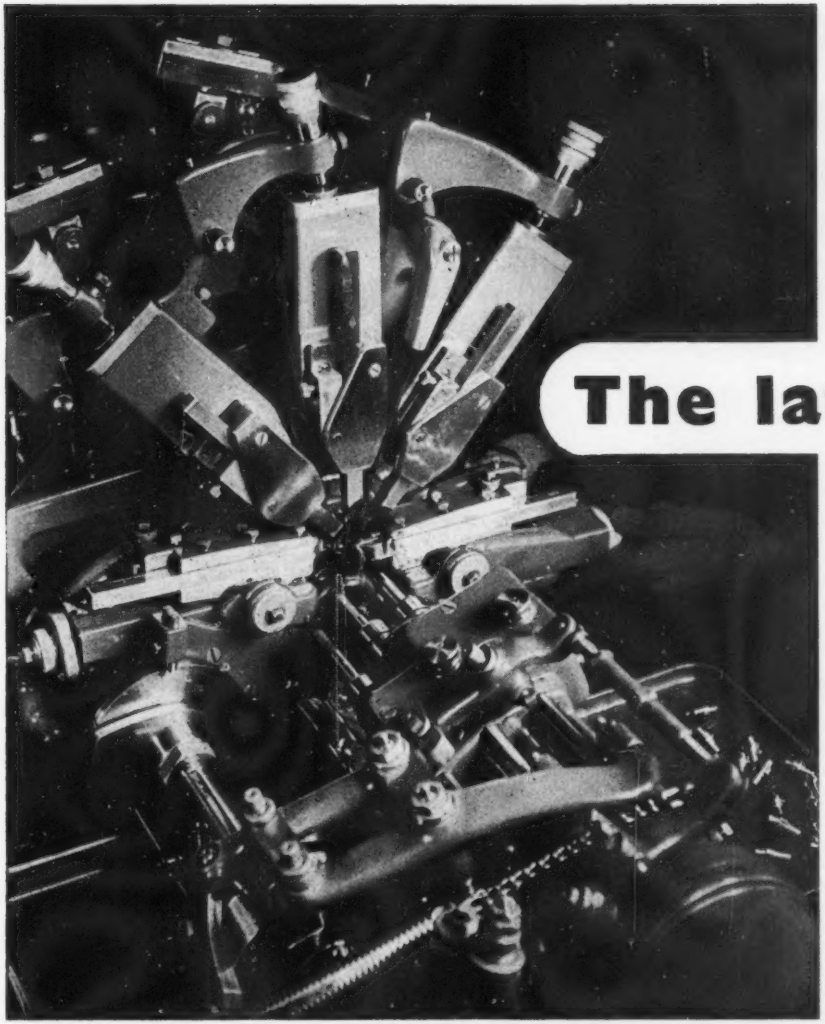

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SLIDING HEAD AUTOMATIC

MODEL R.16

● This model R 16, built by the world's largest and oldest producers of Swiss-type automatics, is the last word in performance, precision and production capacity.

Stock capacity ⅛in. dia., with a maximum turning length of 3½in. or 6in., according to type of cam. 28 spindle speeds 485 to 5,450 r.p.m.

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- Handles up to 10" x 4" thick ferrous or non-ferrous metals.
- Equally suitable for grinding plastics, wood, stone, glass etc.

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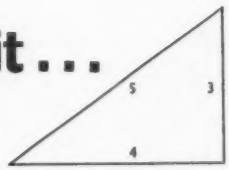

The '3-4-5 trick' has been acknowledged by builders from ancient Grecian times as the only accurate method of laying out right angles.
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By this means angles could be set and measured to an accuracy of a minute of arc, and later when measuring methods improved ± 10 seconds of arc became an easily held angular tolerance. The sine bar principle was applied to adjustable angle plates and the sine table as we know it was born.

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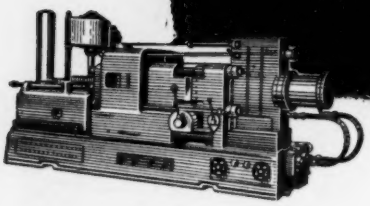

Harper quality covers Grey Iron, Spheroidal Graphite Iron (Mond Nickel Licence) and Meehanite castings.
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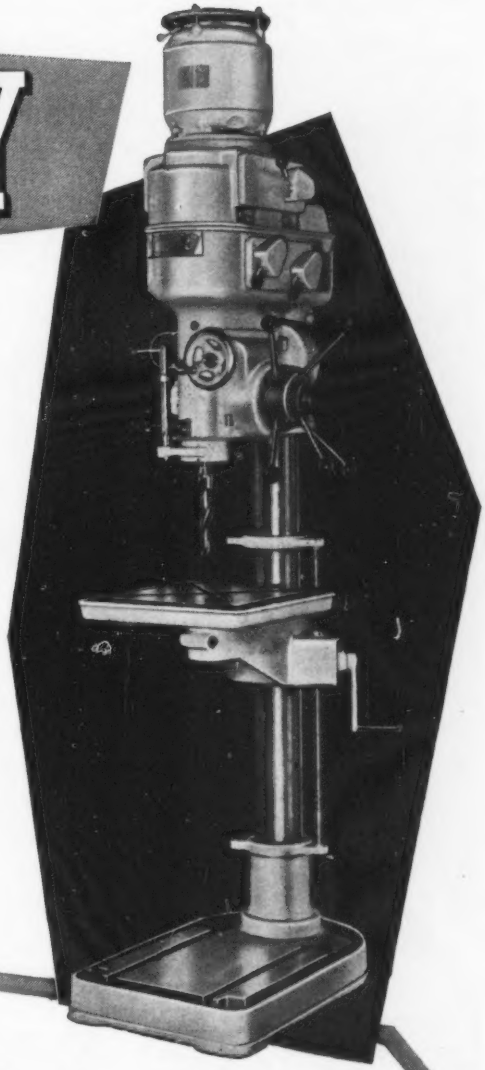

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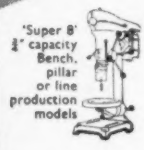

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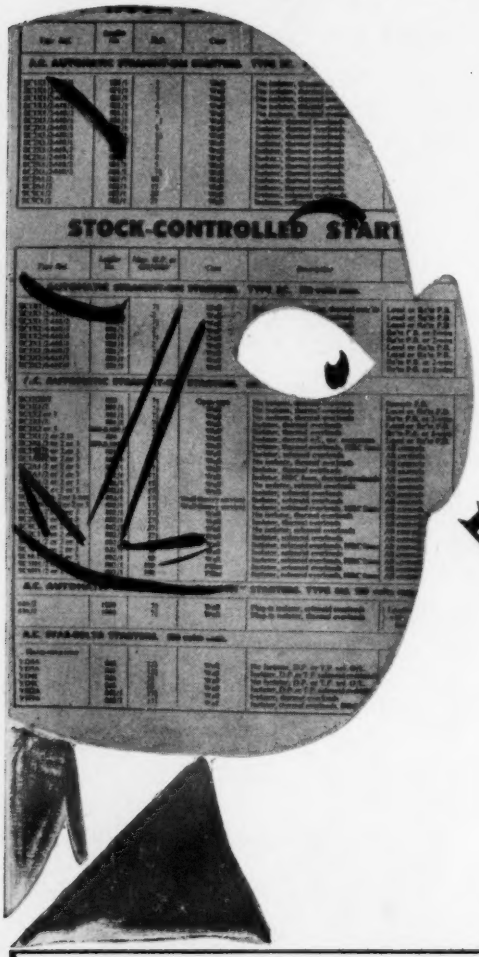

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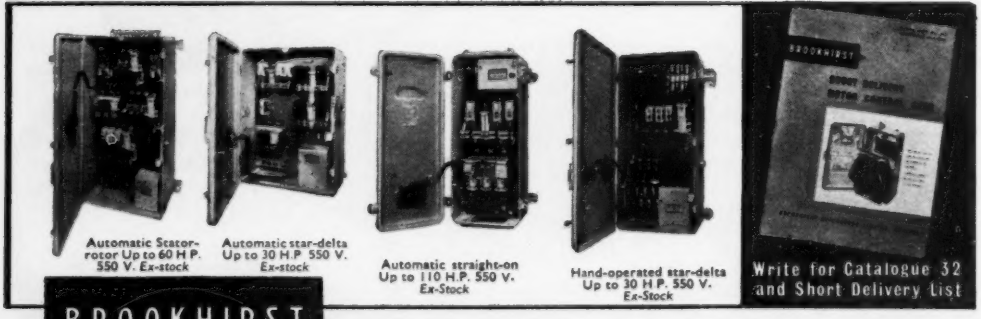
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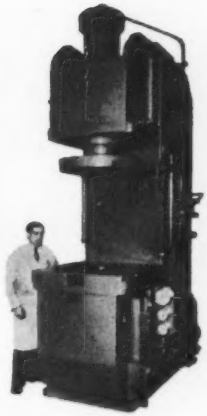
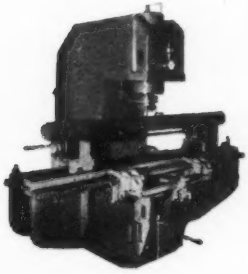
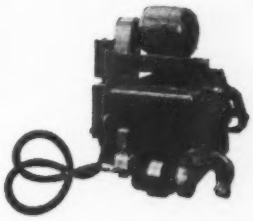


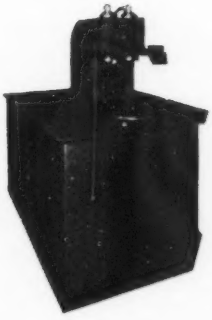
Hi-Ton 150-ton Open Throat Drawing Press.



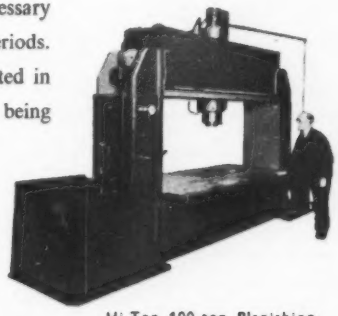
Hi-Ton 75-ton Press equipped with hydraulically operated loading equipment enabling bars to be loaded onto the straightening equipment outside the throat area of the machine.



Hi-Ton HTR.20 Riveting Unit consisting of pump unit and cylinder assembly.



Hi-Ton Indexing Table Machine with two down stroking rams each of 15 tons capacity



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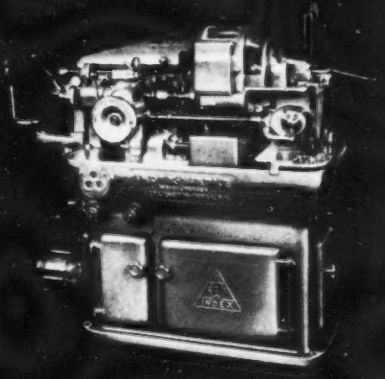

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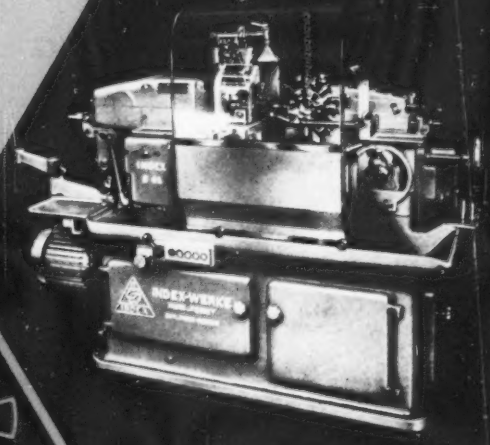

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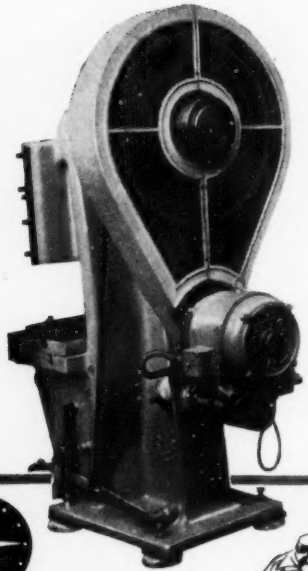

2.0 p.m. Problem. How to get this 50-ton press installed and working with the least possible production delay. How to hold it safe and levelled on an uneven floor riddled with pipe lines. Method chosen: "Barrymount" Levelling Machine Mounts, as specified by Cementation experts. Time taken: **two hours ten minutes.** This is how:—

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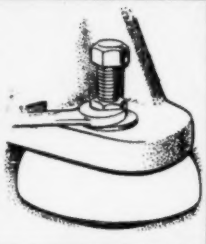

4.10 p.m. Working. No long expensive production delays while the concrete dries out. Directly the press is connected to power, it's ready to work. Its "Barrymount" Machine Mounts act as highly efficient shock and vibration isolators; hold it firm and safe without a sign of 'walking'.

Where did all this happen?

We've taken a typical problem here; but it *could* happen in your machine shop. Cases like it crop up almost daily, all over the country, and they're all solved the same way. "Barrymount" Machine Mounts were introduced here from the U.S. some three years ago. Since then their use has spread to thousands of machine shops throughout Britain. Users report installation times cut from days to minutes; floor space better used; greater production flexibility and a dramatic decrease in structure-borne vibration and noise.

It's not uncommon for "Barrymount" machine mounts to pay for themselves at installation in terms of production time gained. It's pretty sure that a pilot set on the next machine you install—or move—could show you similar savings, too. If you'd like full technical details, get your secretary to fill in this coupon.

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Modern machine tools belong on

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TEN FEATURES OF THE COLLET

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- Only eleven collets required to hold any diameter bar between $\frac{1}{8}$" and $1\frac{1}{2}$" whether English, metric or decimal sizes.
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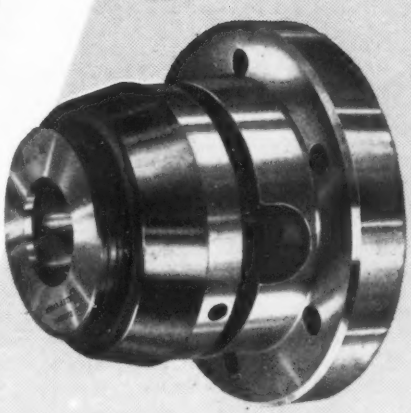
- Maximum feeds and speeds obtainable without risk of slipping and scoring or distortion of components.
- Constant parallel grip throughout complete range of collet.
- Thin walled components gripped firmly without damage.

This startling new workholder provides all the advantages of conventional spring collets combined with the flexibility of an adjustable jaw chuck. One "Multisize Collet" will replace at least 9 conventional collets and only 11 collets are required to cover a range of $\frac{1}{8}$" to $1\frac{1}{2}$". Several years of research and testing lie behind the "Multisize Collet" Write today for fully illustrated brochure.



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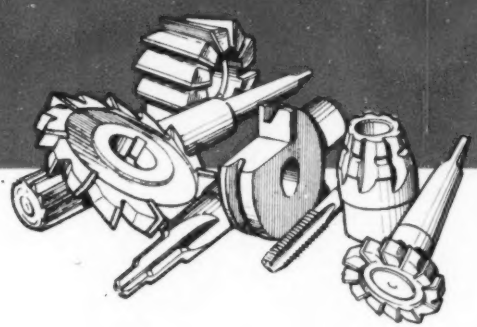

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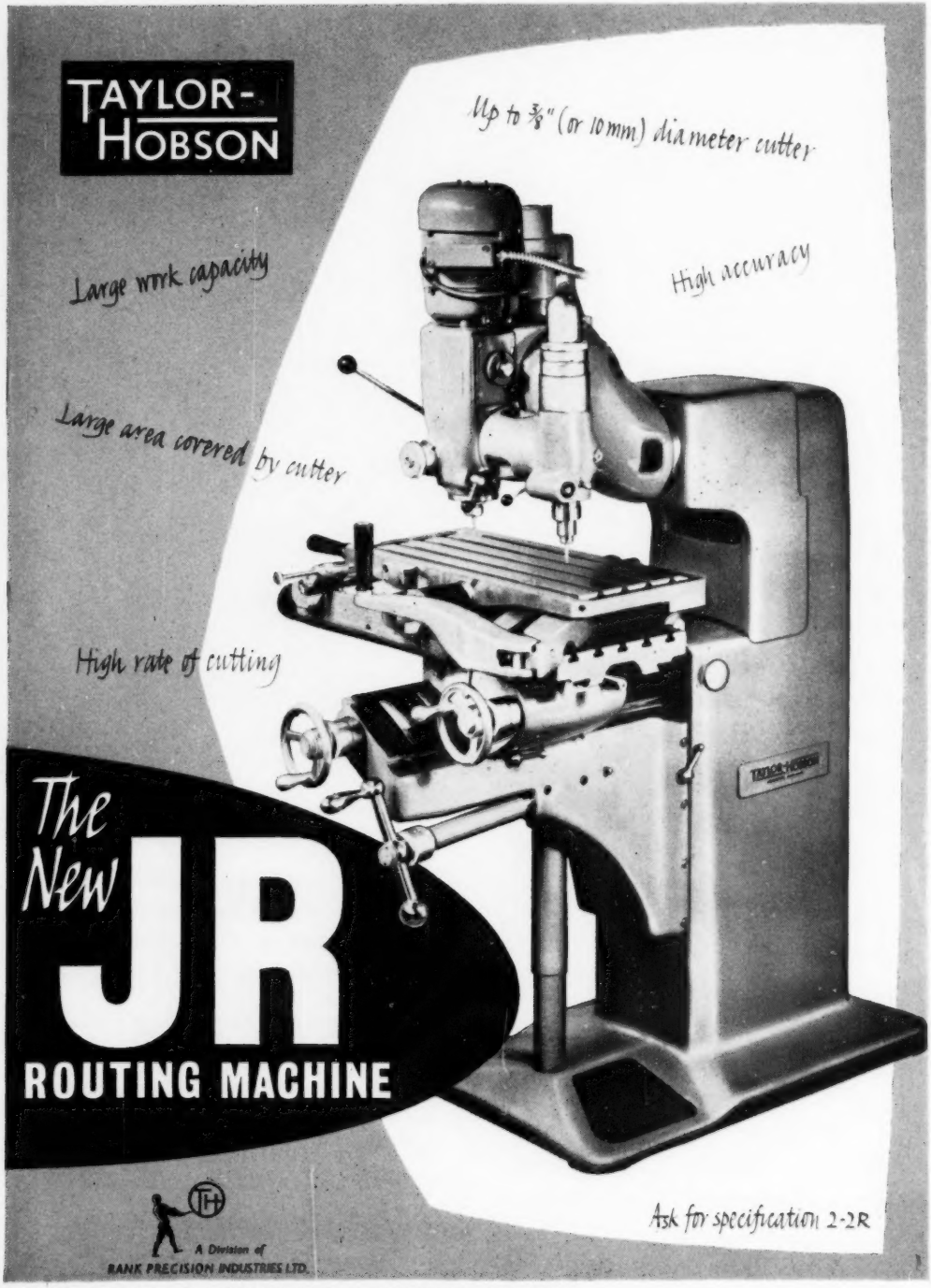

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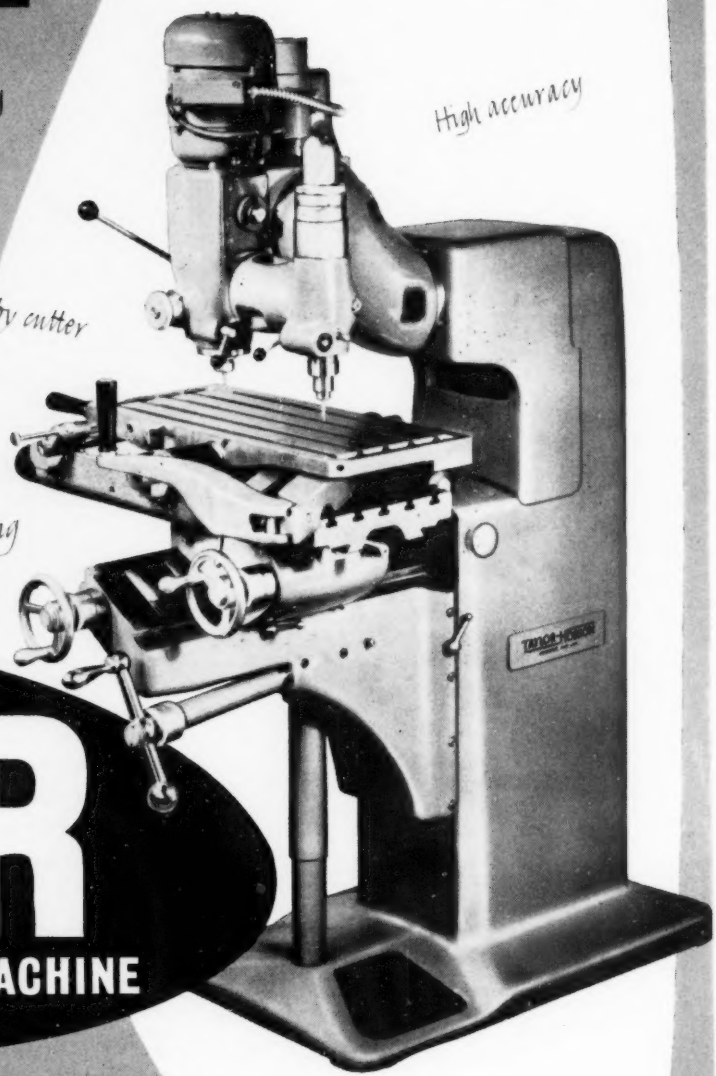
High rate of cutting



The New JR ROUTING MACHINE

A Division of RANK PRECISION INDUSTRIES LTD.

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TAYLOR, TAYLOR & HOBSON LTD., LEICESTER, ENGLAND

JR 19

SEEGER CIRCLIPS
are 360° safe
Automotive Engineering Limited
One of the Sheepbridge Engineering Group
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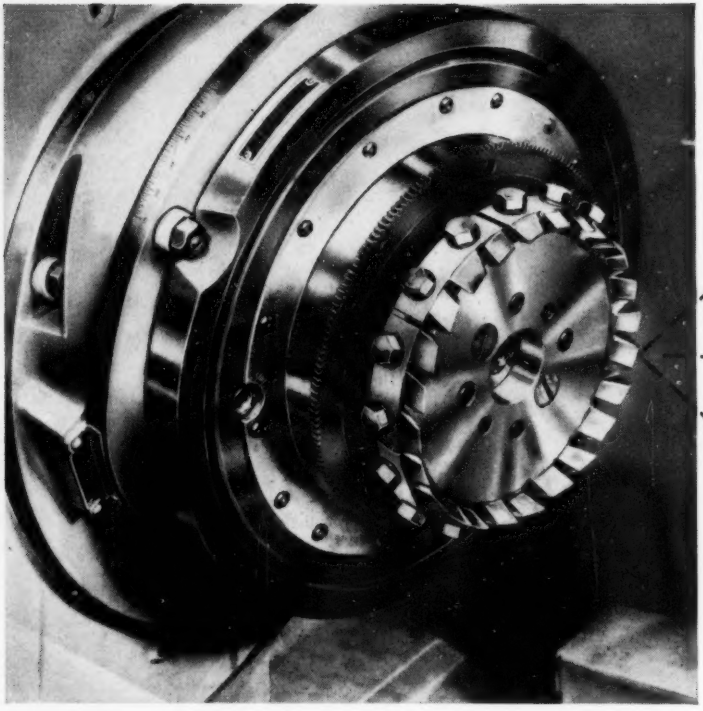
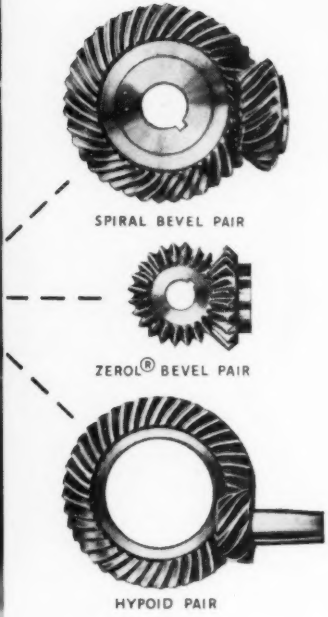
One Generator using one cutter produced these three different gear pairs!





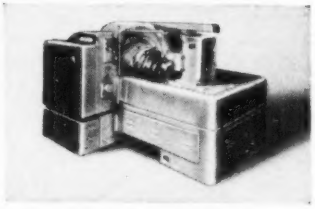
The new Gleason No. 116 Hypoid Generator used one Unitool Cutter to generate the three gear pairs shown above. Only five additional Unitool Cutters are needed on this generator to cut spiral and Zerol bevel gears of any ratio, and hypoid gears of 3 : 1 ratio and higher; up to 18in. pitch diameter.

The Unitool Method was developed especially for use with the No. 116 Hypoid Generator, and its smaller counterpart, the No. 106 Hypoid Generator. This new method requires only a small tooling cost to cover the entire range of both machines.

It is intended for the production of small quantities of bevel and hypoid gears, and does not replace the cutting methods now in use for mass production. When using these methods, the No. 116 Generator is substantially faster than previous models.

In addition, the new features incorporated on the No. 116 offer simplification of tooth bearing development, improved quality and much easier set-up and operation.

We shall be glad to send you information on the No. 116 Hypoid Generator and the Unitool Method for producing small quantities of bevel gears.



The No. 116 Hypoid Generator cuts spiral bevel, Zerol Bevel and hypoid gears up to 18in. pitch diameter, any ratio up to 10:1, any pitch 2 DP and finer.

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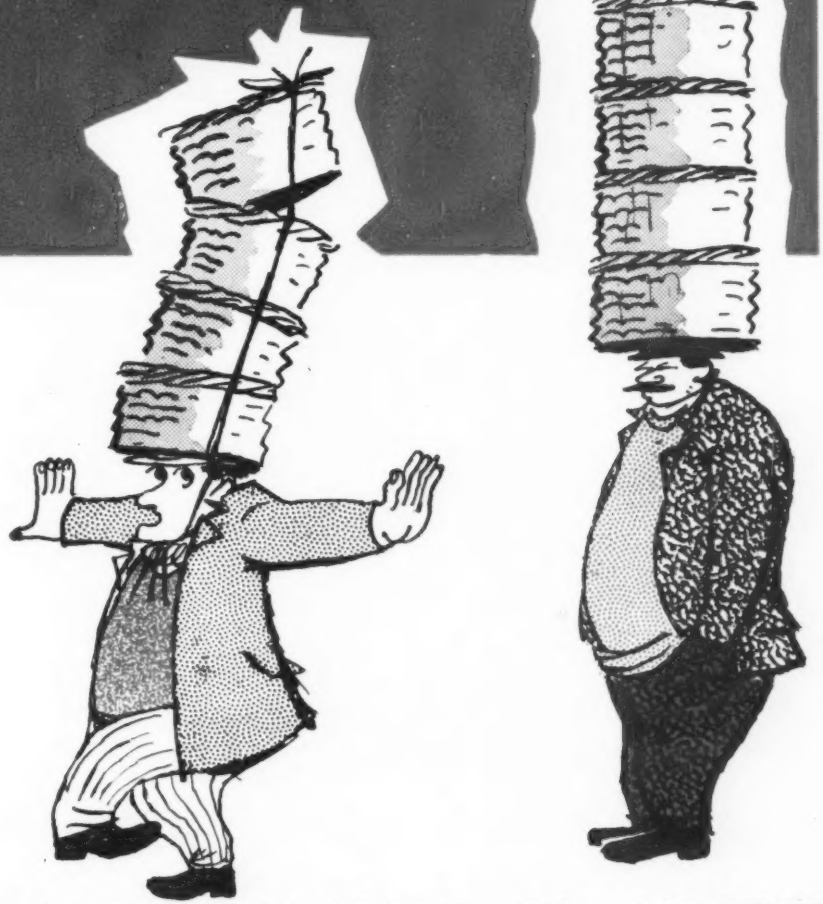

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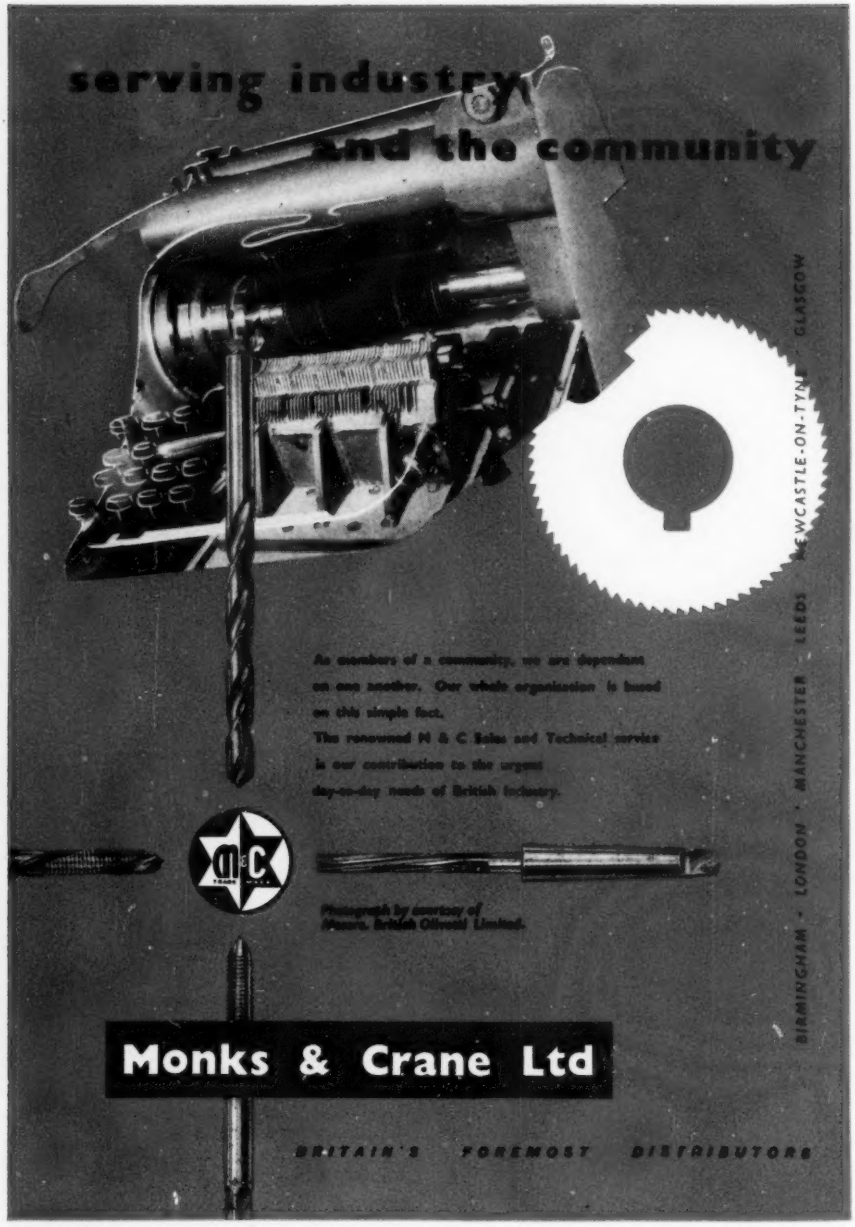
serving industry
and the community
As members of a community, we are dependent on one another. Our whole organisation is based on this simple fact.
The renowned M & C Sales and Technical service is our contribution to the urgent day-to-day needs of British Industry.
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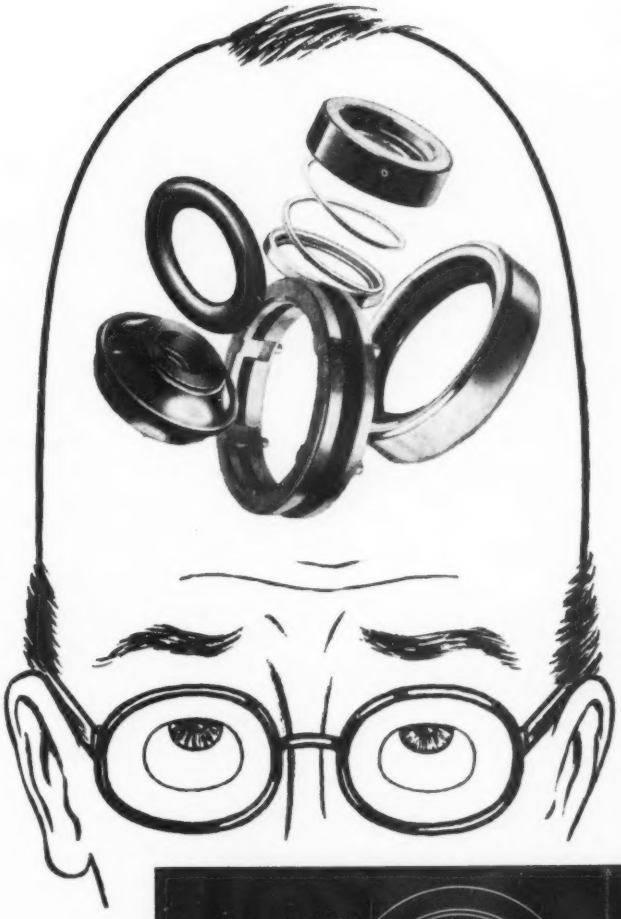

think of SuPERFECT

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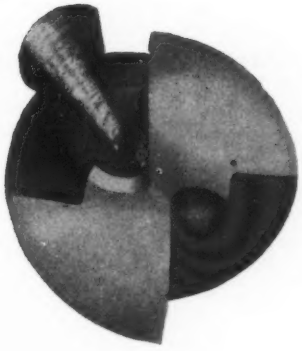

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Under closely controlled tests at one of the largest Constructional Engineering Works in the country, *SPEEDICUT "CHIPBREAKER" DRILLS* 15/16" diameter, dry drilling mild steel plates, each drilled an average of 3108 holes between regrinds. This is reported as 50% more than any other type of drill tested at these Works.

Take advantage of the latest techniques in toolmaking—
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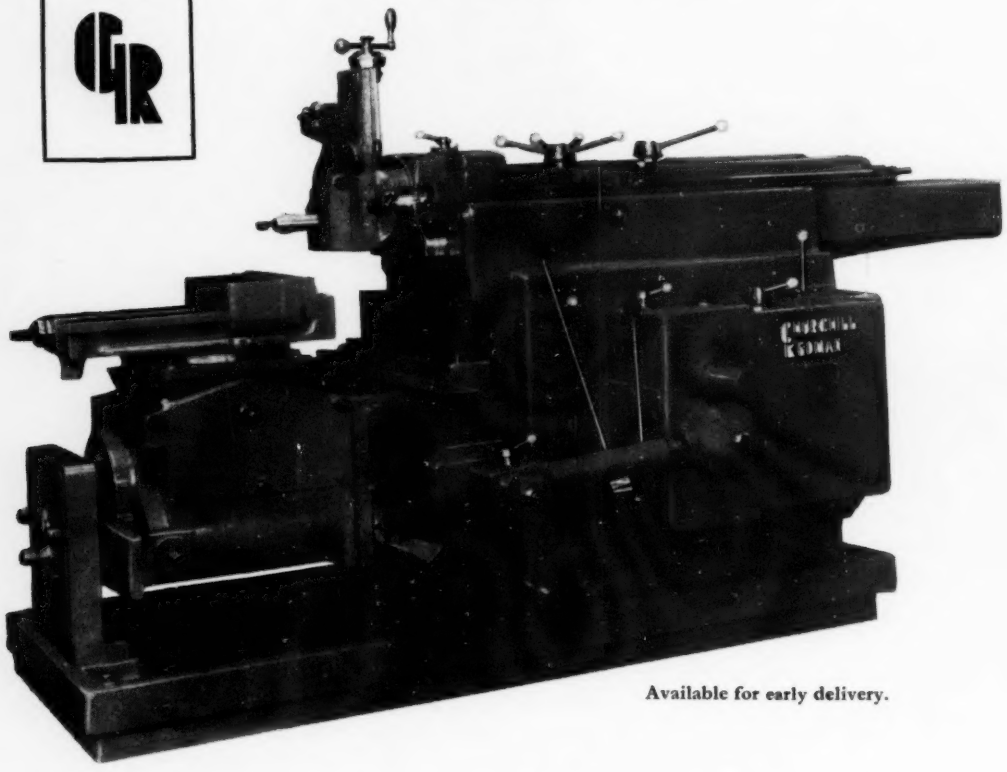

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- Rigid front table support for heavy cuts.
- Feed and power elevation to table.
- Totally enclosed cam-operated feed mechanism.

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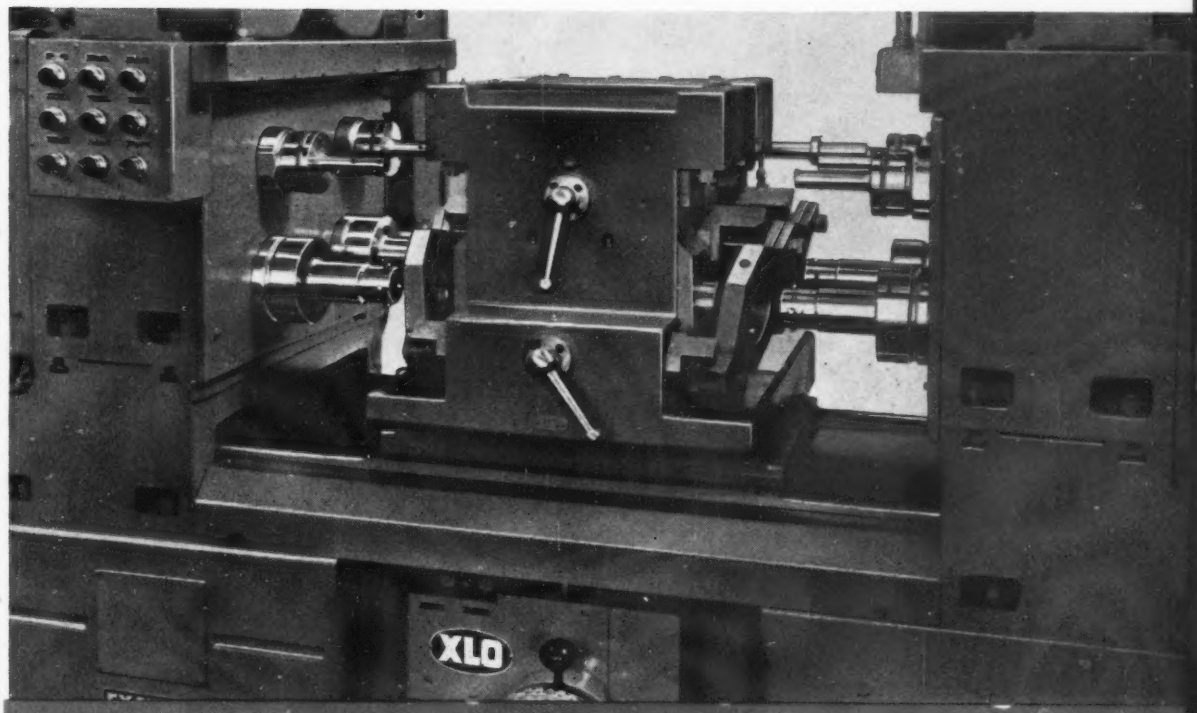

* 220 per hour!

This is a typical EX-CELL-O set-up in a well-known automobile factory, where EX-CELL-O machines have proved their ability to reduce costs and improve finish on a wide variety of work. Both the large and small ends of the rods are machined and the production rate is 220 pieces per hour. We invite you to investigate the cost reducing possibilities of EX-CELL-O machines for your own work. No obligation.

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STYLE 1112 C SENIOR
PRECISION BORING MACHINE

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The fastest method of grinding two surfaces simultaneously!

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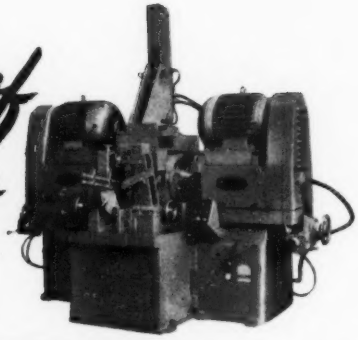
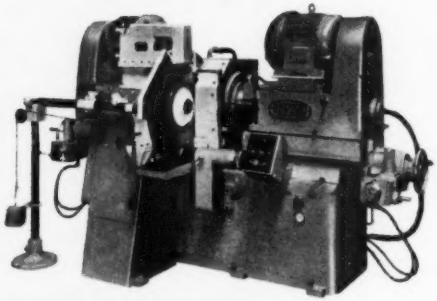
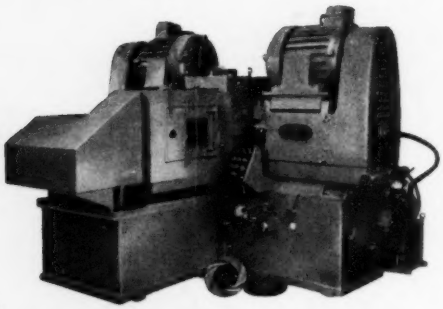
✱ Illustrated here are but a few of the very many types of 'Duplex' surface grinding machines that we manufacture.



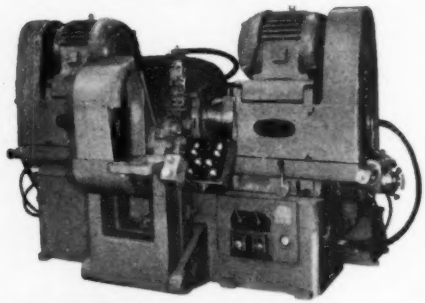
CIRCLIPS **30in. Type ADD/F**



CALCULATOR PARTS **20in. Type HDD/C**



BRAKE DISCS **30in. Type ADD/H**



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Our technical representatives are ready, able and willing to co-operate with you.

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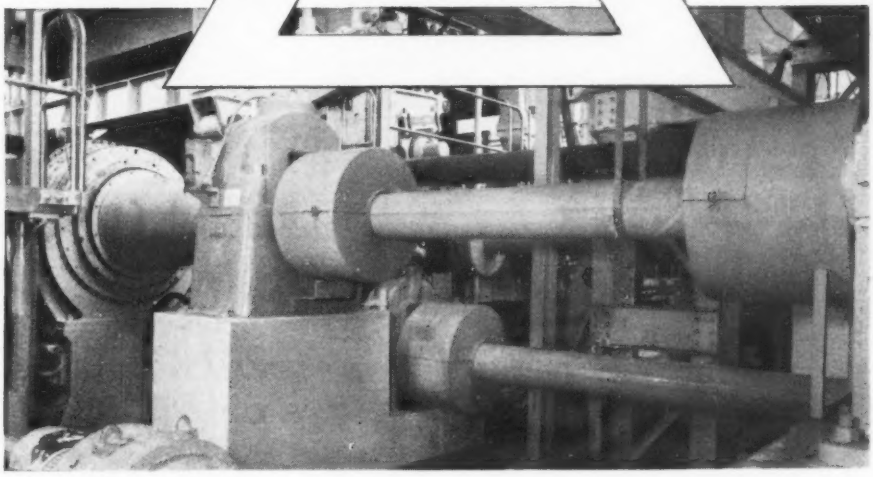

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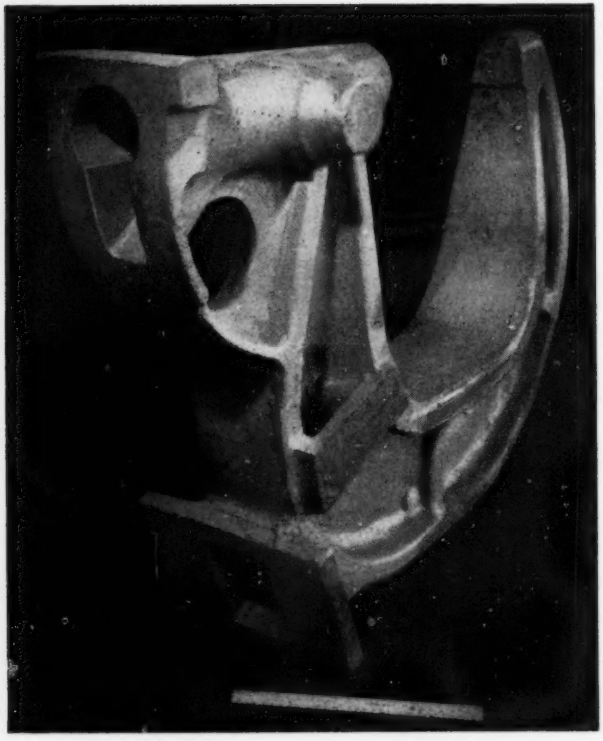

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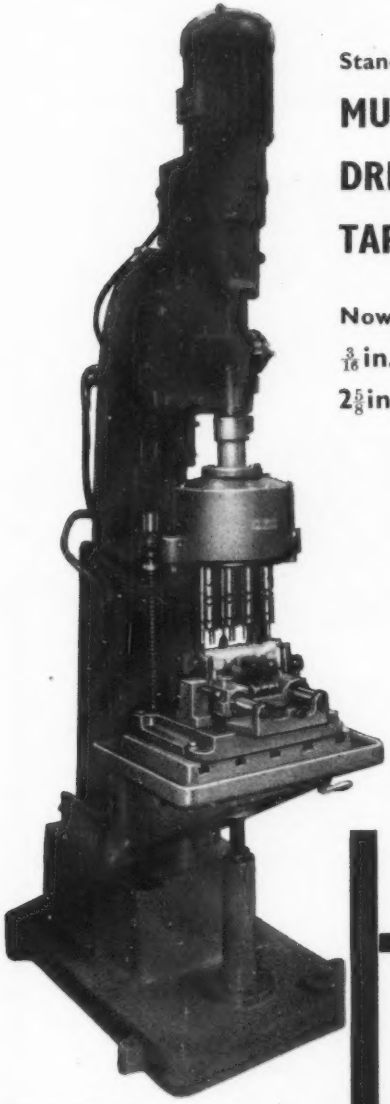

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MULTI SPINDLE DRILLING AND TAPPING SETS

Now available in

$\frac{3}{16}$ in. to $\frac{35}{64}$ in. capacity—

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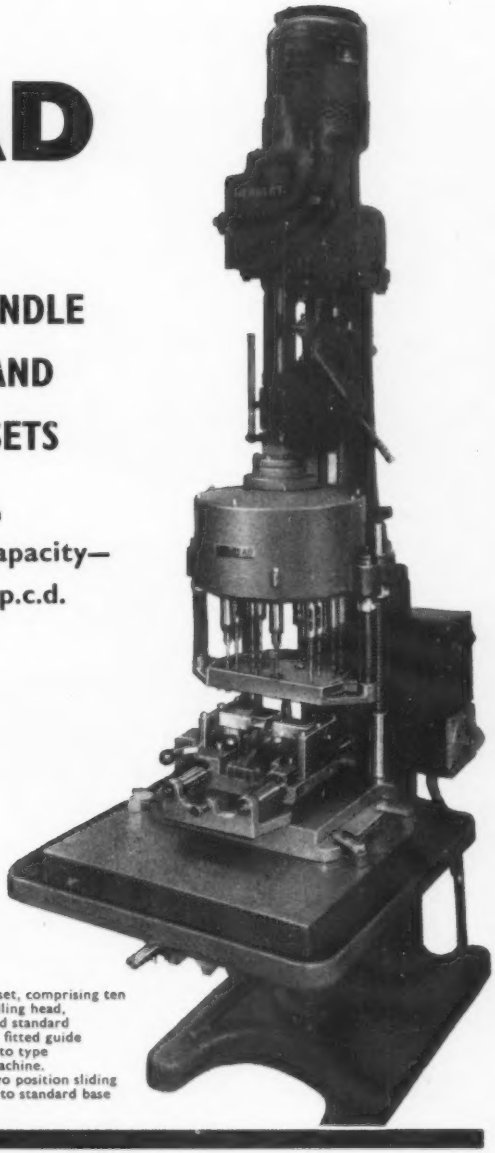

Standard H.13 set, comprising ten spindle multi-drilling head, jig bush plate, and standard base casting with fitted guide pillars, mounted to type "C" Herbert Machine.
Note: Special two position sliding fixture mounted to standard base casting.

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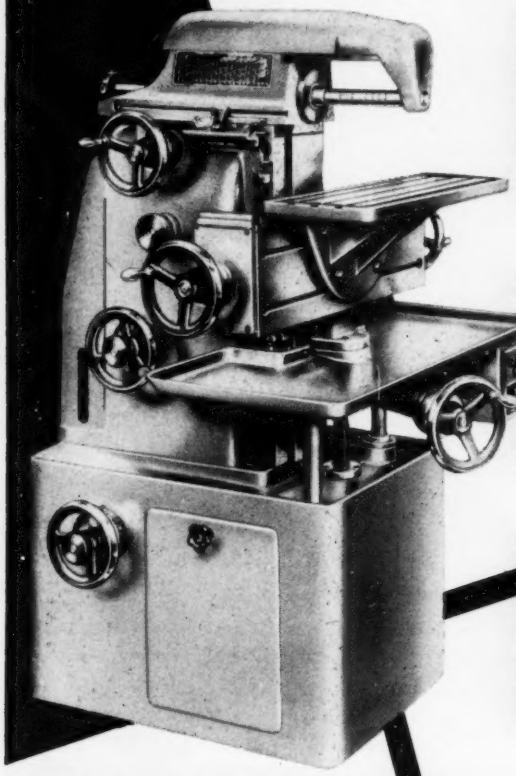
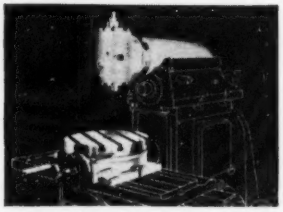
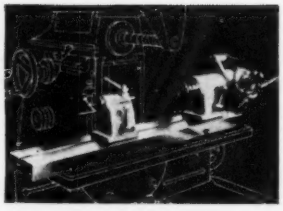
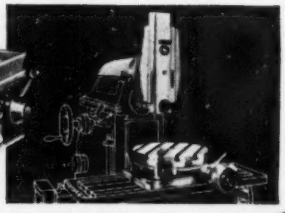




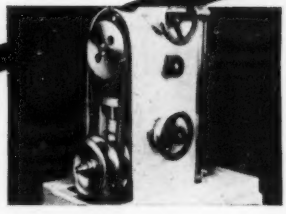
Vertical Milling Head & Universal circular table



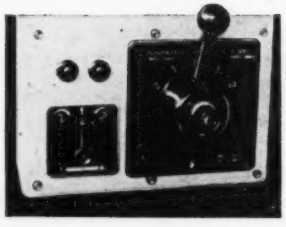
Universal Dividing Head on auxiliary swivelling platen



Slotting Head & Circular Table



Infinitely variable speed range from 60 to 2,500 r.p.m. Infinitely variable feed from separate fitted motor



Patented single lever switch for easy control of milling spindle rapid traverse & power feed

Table Size 26¾in. by 9in.

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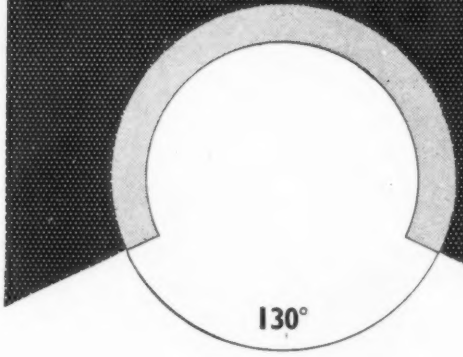
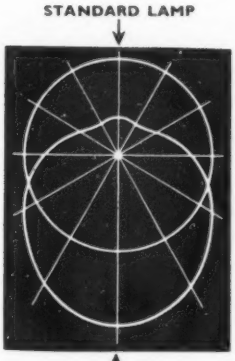
Get more light at no extra cost! fit PHILIPS *Reflectalite*



—the fluorescent tube that now gives even more light in the useful direction



Light distribution comparison diagram.

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Available in Cool White, Cool White de Luxe, Warm White.	**SWITCH START. 4' 40W. 13/9d. plus P.T.** **5' 80W. B.C. or Bi-Pin 14/9d. plus P.T.** **INSTANT START. 1/- extra.**

Next time you need a tube—fit a **PHILIPS** *Reflectalite*

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PHILIPS ELECTRICAL LTD · LIGHTING DIVISION · CENTURY HOUSE · SHAFTESBURY AVE · LONDON W.C.2
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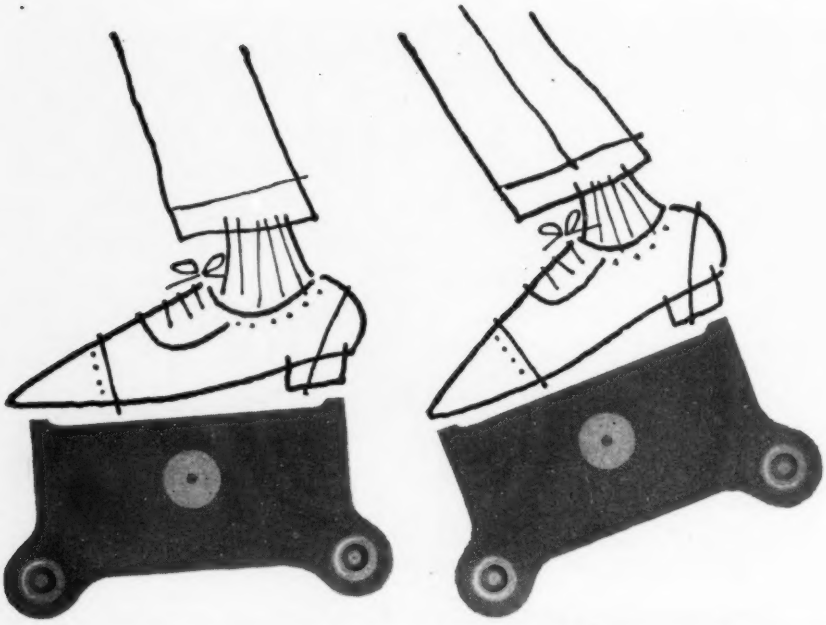

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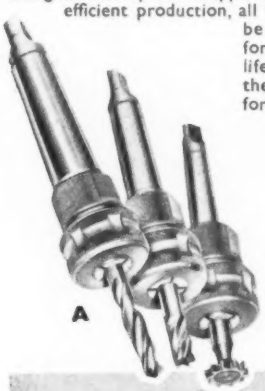

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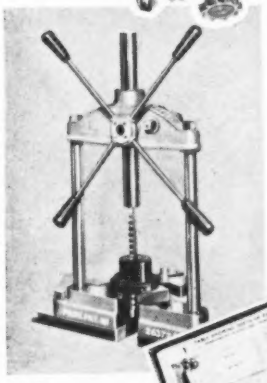
B. TWO-SPEED PRESSES. Daylight 16$\frac{1}{2}$in. Between columns 14in. Reduction ratios 16-1 and 50-1. Six table slots—$\frac{3}{4}$in. to 3in. Heat treated gears. Ground ram in honed bore.

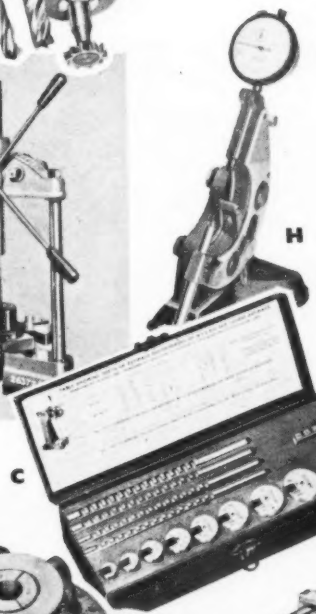
C. KEYWAY BROACHES. Four sets cover a range from $\frac{1}{16}$in. to $\frac{1}{2}$in. Easy to set-up, but perfect keyways, parallel or taper. 18% T. H.S.S. broaches.

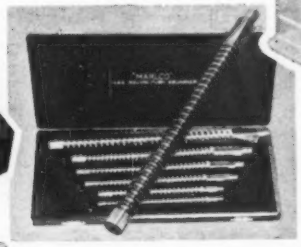
D. INDEXING AND DIVIDING ATTACHMENTS. A full range to cover all needs. Simple, accurate, robust. Vertical and horizontal models, or combined if required.

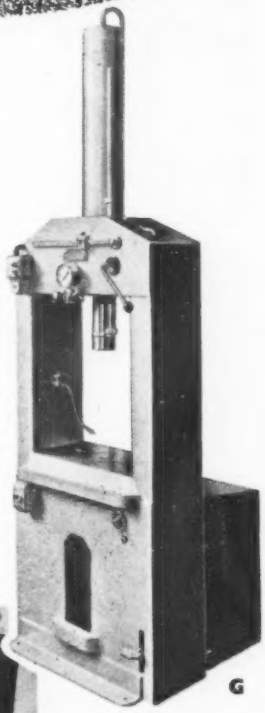
E. THE 'EQUIMASTER' SPACING ATTACHMENT facilitates accurate drilling of equi-spaced holes on pitch circles up to 7in. dia.

F. H.S.S. SQUARE PUSH BROACHES. Ten standard sizes from $\frac{1}{16}$in. to $\frac{1}{4}$in.



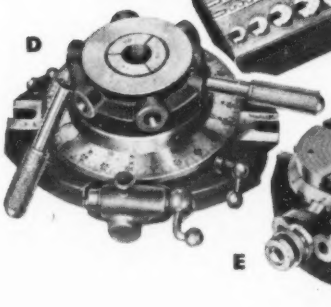


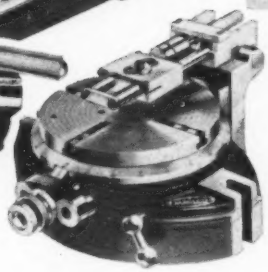




G. HYDRAULIC PRESSES. Models from 12 to 100 tons. Three speeds and tonnages. Long stroke and daylight.

H. THREAD MEASURING COMPARATOR. Effective diameters of R. and L.H. threads up to 2$\frac{1}{2}$in. dia. Whit., U.N., U.S. Metric and B.A.





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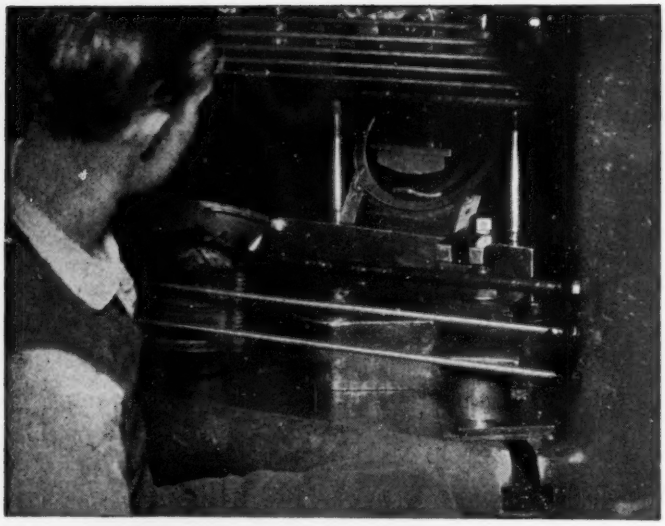

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"476". For tools operating under severe conditions of wear and abrasion or when maximum runs are desired. Air hardening, machinable. Applications include dies and punches for blanking steel sheet and plate, high silicon transformer materials, stainless steel and iron, brass, copper, zinc. Also for deep drawing dies, cupping dies, forming dies.

"L.T.A.H." Deep hardening in air at 840 deg./860 deg. C. with minimum distortion. Tough and abrasion resistant. Low decarburization. Machinable. Specially for tools of heavy or intricate section, heavy forming dies, blanking dies, trimming dies, notching dies, heavy duty punches, spindles, stripper plates, bending tools.

"S.C.V." A hard, tough steel which resists sinking. For cutting dies, drawing and rivet dies, stamping and blanking dies, pressing dies, coining dies.

"NEWHALL". An oil hardening non-deforming steel. Has a wide range of applications in press tool work when it is not desired to use more highly alloyed steels.

"PAX No. 2". Shock resisting steel with high impact strength and good wear resistance. For punches and dies used on thick gauge materials and subject to heavy shock.

Send for booklet B.15, describing Tool and High Speed Steels.

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SANDERSON

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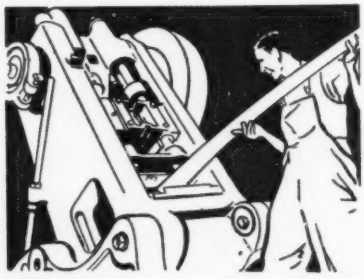
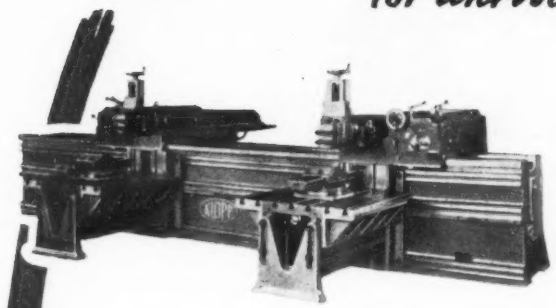


SANDERSON BROTHERS AND NEWBOULD LIMITED, ATTERCLIFFE STEELWORKS, P.O. BOX 6, NEWHALL ROAD, SHEFFIELD 9

KLOPP

high speed SHAPING MACHINES for unrivalled cutting capacity



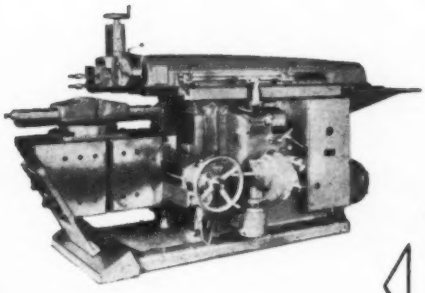
For high performance and accurate work on all kinds of production, the range of Klopp fully hydraulic heavy duty shaping machines receive wide acclaim. They are designed for taking the heaviest cuts and because of their high power potential and extreme rigidity have numerous applications in the medium and heavy engineering industries.

FULLY HYDRAULIC TRAVERSING HEAD HIGH SPEED SHAPERS

Built with various bed lengths and with one or two heads, these machines are specially designed for high speed shaping of heavy workpieces. They are provided with infinitely variable cutting speeds ranging from 26 to 110 f.p.m. and fast power traverse of the ram in either direction with constant speeds for the full length of the cutting stroke. Feed is automatic and adjustable by increments of 0·01" from 0·01" to 0·08". The cutting head can be swivelled 45° on either side. As an extra, a motorised vertical table feed is available.

Brief Specification

Max. length of stroke :	39½"
Max. planing width :	from 59" to 256"
Table area :	39½" by 20½"
Vertical movement of table and tool slides :	30¾" and 8½"



FULLY HYDRAULIC SHAPING MACHINES

These machines exhibit the same robust characteristics as the traversing head types, and feature infinitely variable ram speeds which are adjustable without stopping the machine. A detachable work-table is provided and rotates through 180°.

Brief Specification

Produced in three sizes.

Max. length of stroke:	26" to 47¼"
Max. planing width:	27½" to 37⅜"
Table area:	24⅜" × 13⅜" to 39½" × 19½"

WICKMAN LIMITED

FACTORED MACHINE DIVISION, FLETCHAMSTEAD HIGHWAY, COVENTRY

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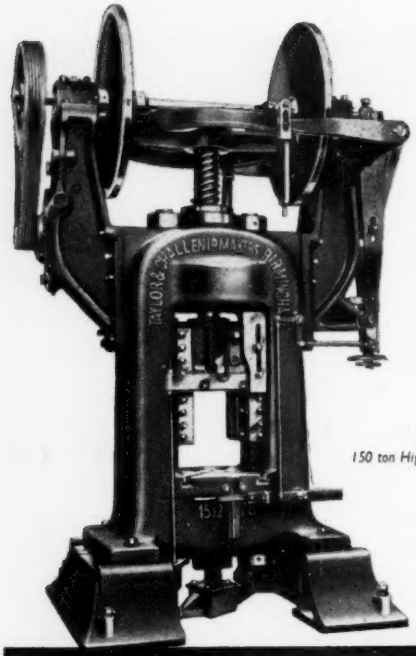
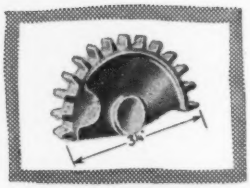
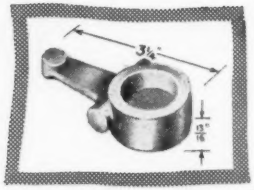


150 ton High Speed Screw Press





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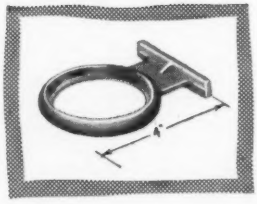

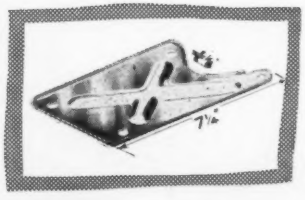

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RANGE INCLUDES :

Models	1.U.	2.U.	5.U.	7.U.
Swing over table	10"	11.6"	15¾"	26"
Distance between centres	15¾"	20" 30" 40"	40", 59", 79"	98½" 118"
Grinding wheel size; dia./face/hole	11.8" × 1" × 3"	13.8" × 1.57" × 5"	17.7" × 2" × 8"	20" × 3" × 8"

Model 5.U.

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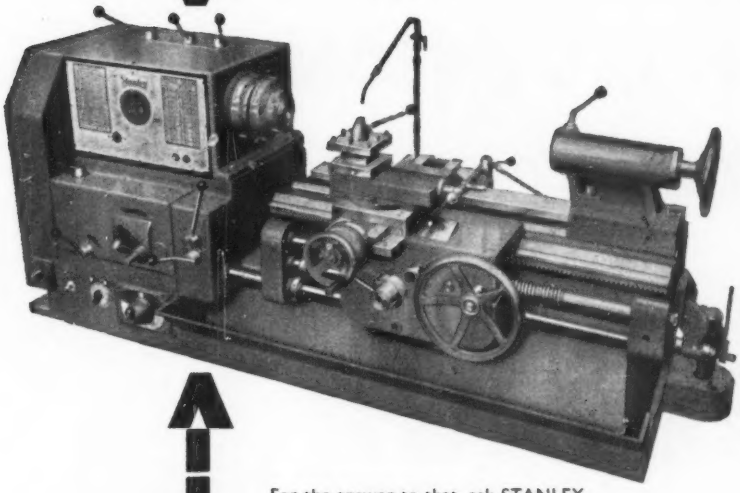
WHAT'S NEW IN SLIDING BED LATHES?



For the answer to that, ask STANLEY.
STANLEY have recently re-designed their 10½ inch Sliding Bed Lathe to incorporate several improvements.
The new Stanley is heavier—has greater horse-power—a wider bed —totally enclosed, built-in electrics. It can be supplied with a back turning rest to turn large diameters the full length of the open gap.
The Stanley Sliding Bed Lathe is really two lathes in one. It can be used as a standard centre lathe and also for large diameter, large width jobs which would otherwise call for a special machine.
Stanley lathes have been serving satisfied users all over the world for more than twenty years. The new model is designed and built to carry on this fine tradition.
All you want to know about the improved Stanley Sliding Bed Lathe is contained in a new catalogue—sent on request.

HIGHLY SATISFIED USERS OF STANLEY LATHES include : ***Mullard Ltd.*** ***Bryant Symons & Co. Ltd.*** ***Laurence, Scott & Electromotors Ltd.*** ***Rosser & Russell Ltd.*** ***Prince of Wales Dry Dock Co. (Swansea) Ltd.*** ***Hobbs Transmission Ltd.***

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This machine with cam-feed, has a six-spindle vertical head for drilling and tapping, as well as a side unit with a two-spindle head. The mechanical revolving table has six stations and two components are loaded at each station. Parts are drilled and tapped vertically and horizontally and all operations are performed simultaneously. Except for loading, operation is entirely automatic. Production 750 per hour.
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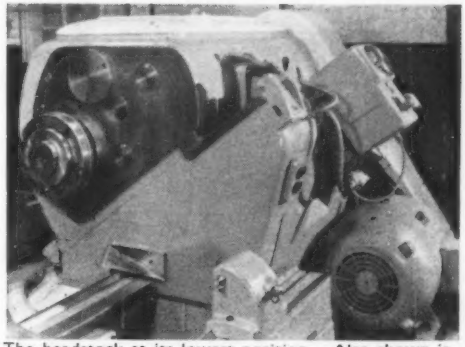
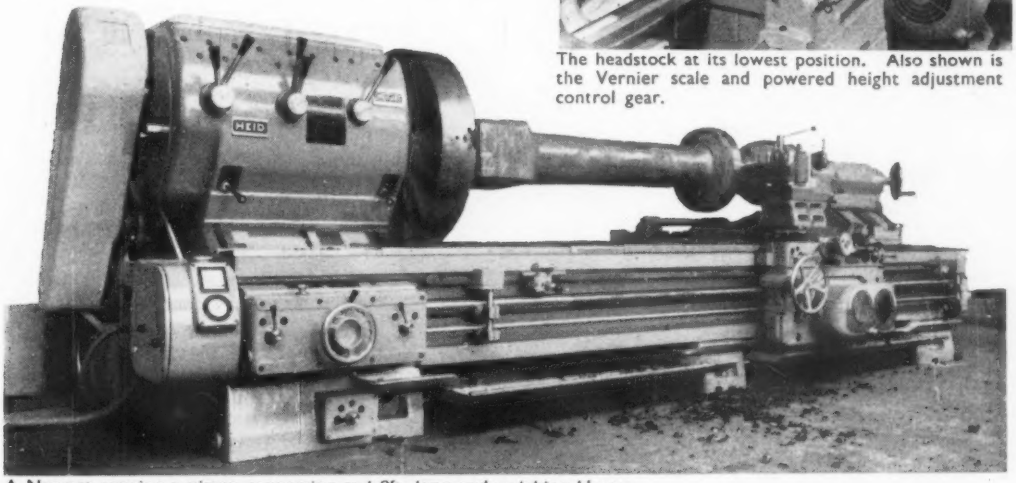
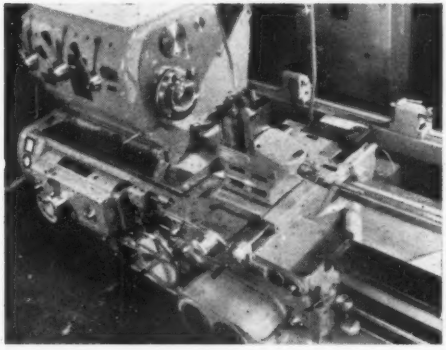
The only Lathe in the world manufactured with variable centre heights (15¾" to 22¼") This adds 50% to the diameter capacity.



The headstock at its lowest position. Also shown is the Vernier scale and powered height adjustment control gear.



A Neomat copying a piston connecting rod 9ft. long and weighing 1½ tons.



Some advantages of the Neomat include:

- ★ **Copy turning over the entire sliding and surfacing capacity.**
- ★ **The cutting forces always fall within the bedways giving a finer finish with no stress on the machine.**
- ★ **Any bedlength supplied to customers' requirements with one or more saddles copying simultaneously.**
- ★ **It can copy through 180 deg. by means of an easily-operated electro magnetic tracer.**

(*Left*) The saddle and headstock showing the controls, adjustable height toolpost and HEID electric copying system.

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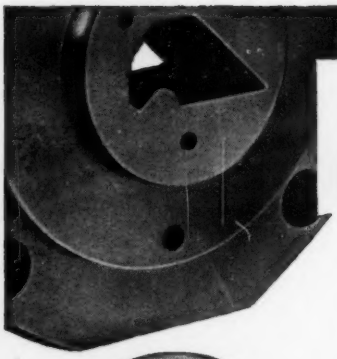

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alloy tool steels

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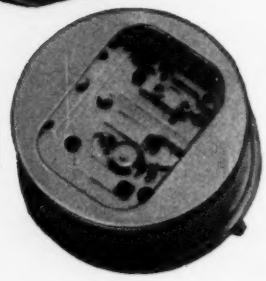

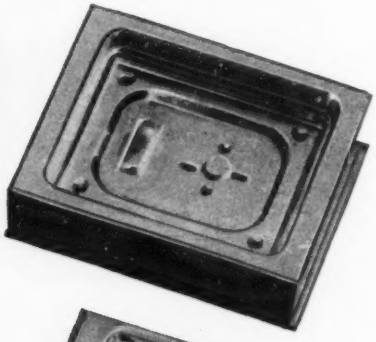

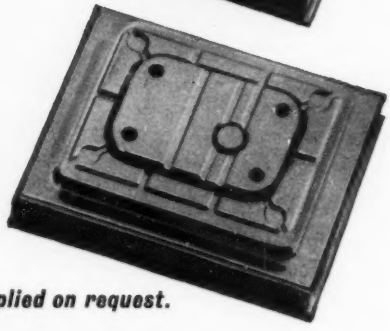

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An air-hardening Nickel-Chrome-Molybdenum Steel which is highly resistant to shock and used for cold-punches, stamping and trimming dies, shear blades and chisels, etc.

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A low-alloy, non-distorting cold-work steel capable of deep and intense hardening and used for high-quality press tools, gauges, taps, and dies, etc.

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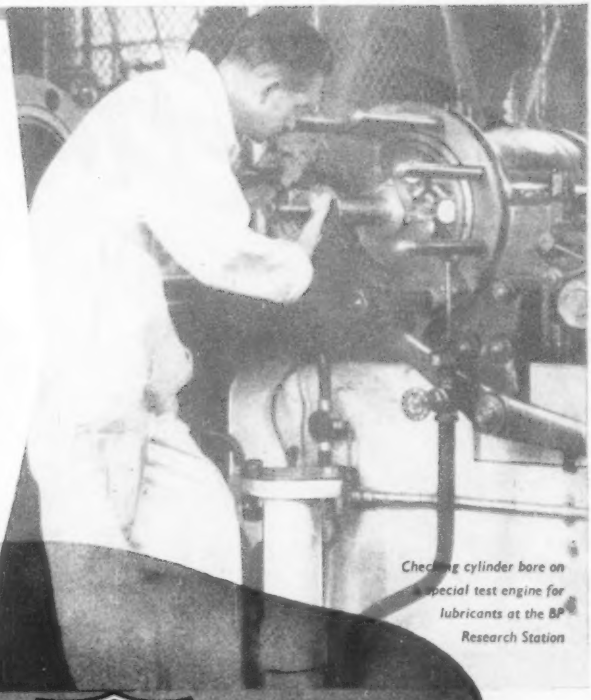

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Vibrationless and silent performance.

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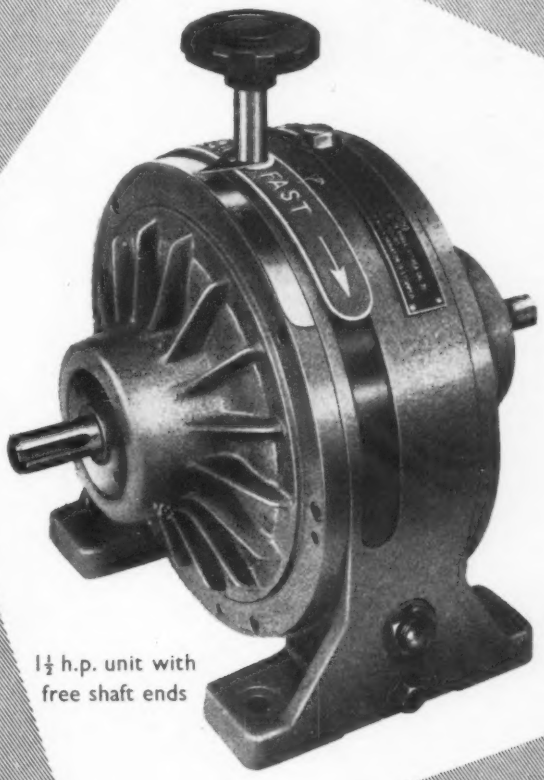

1½ h.p. unit with free shaft ends

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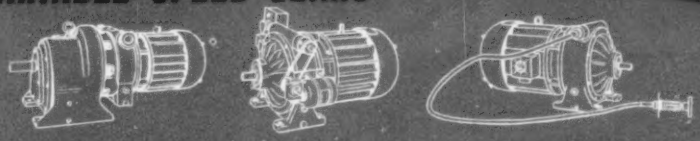

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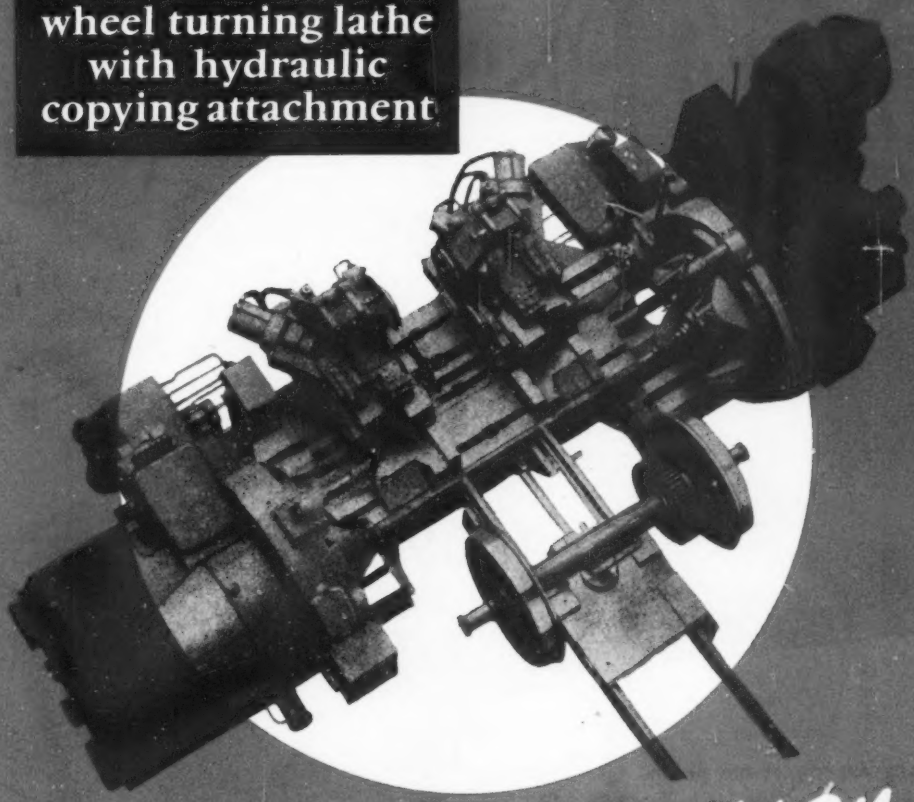

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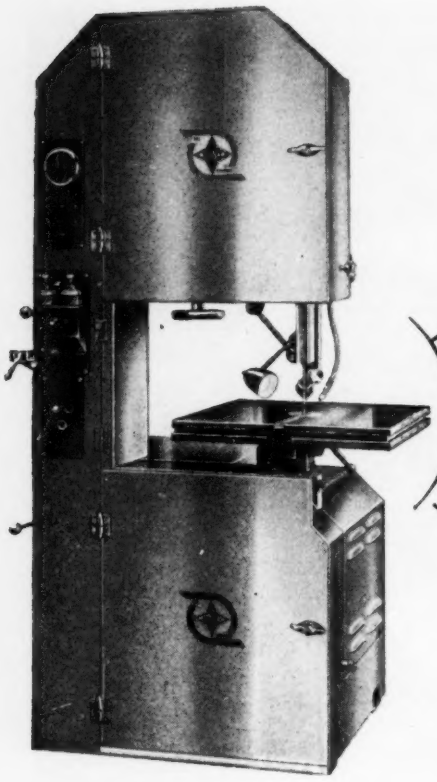

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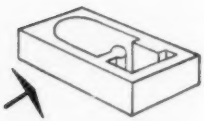

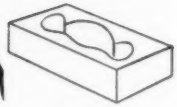

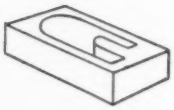

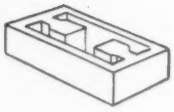

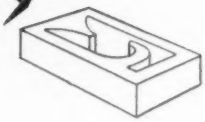

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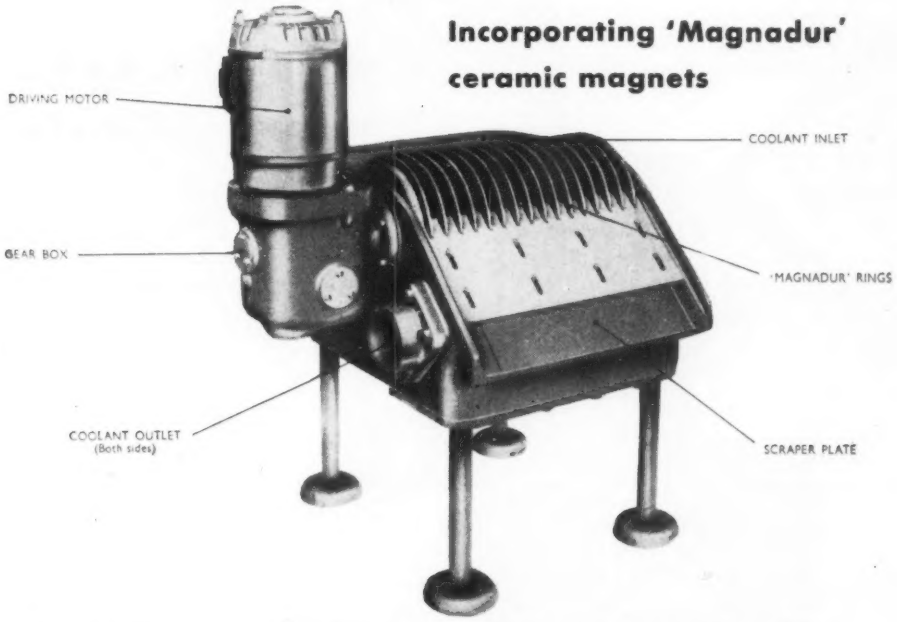

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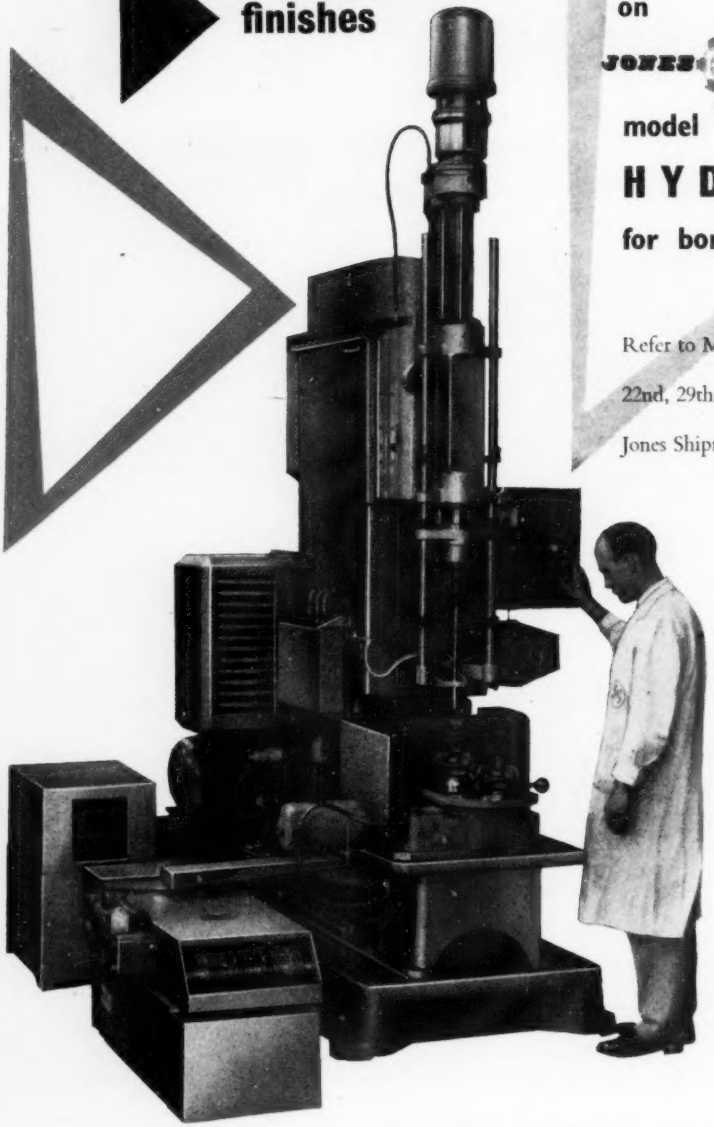

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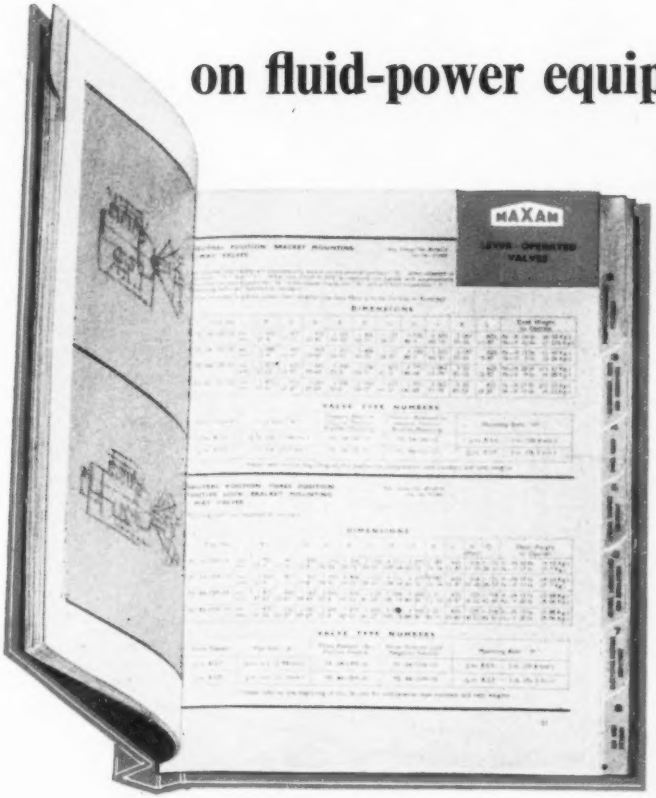

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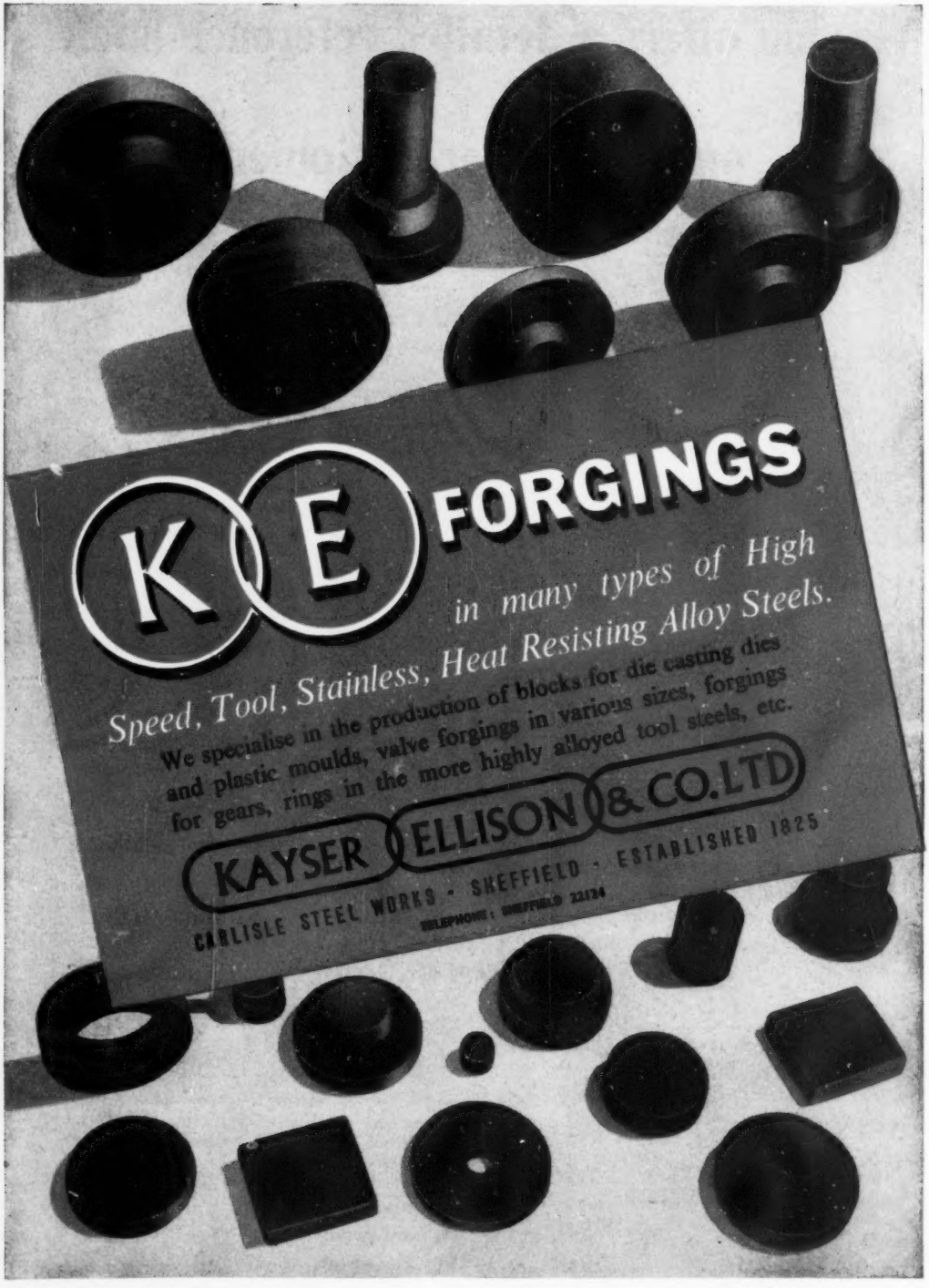
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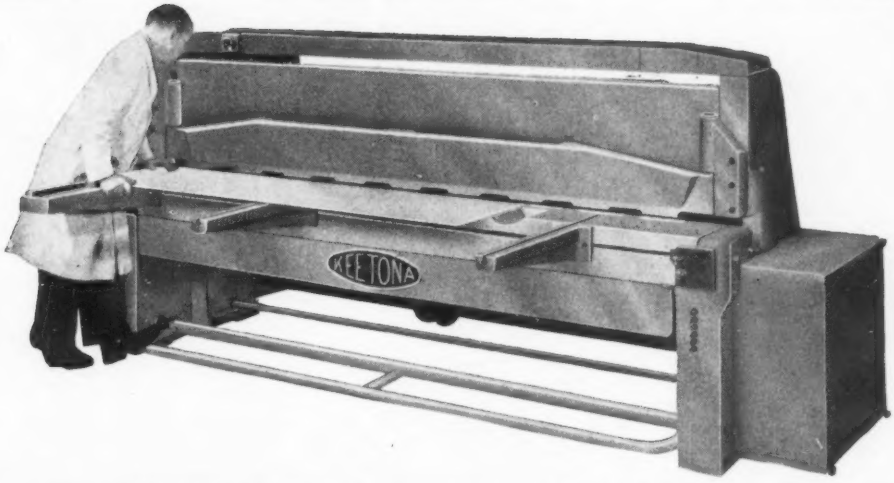

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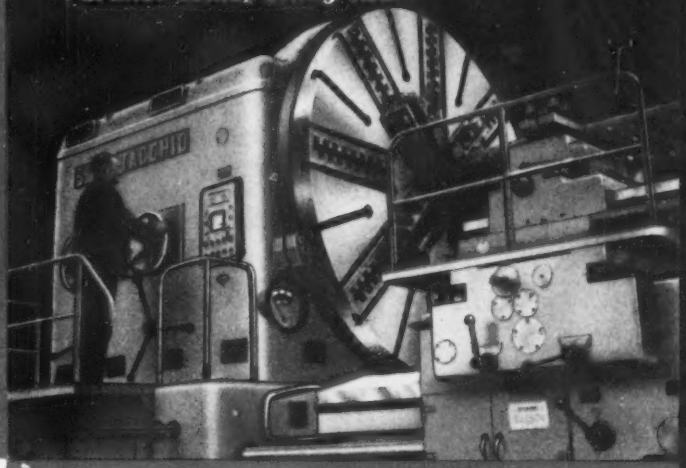

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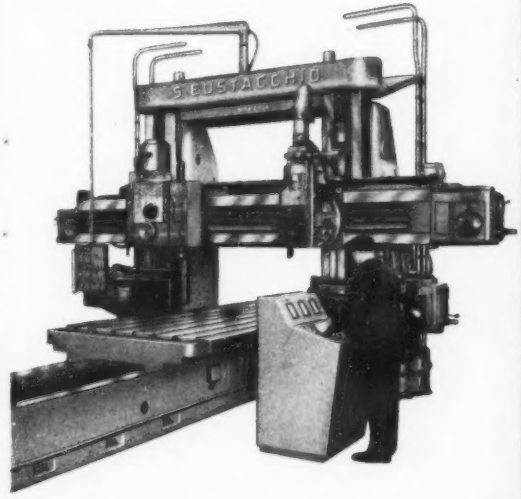

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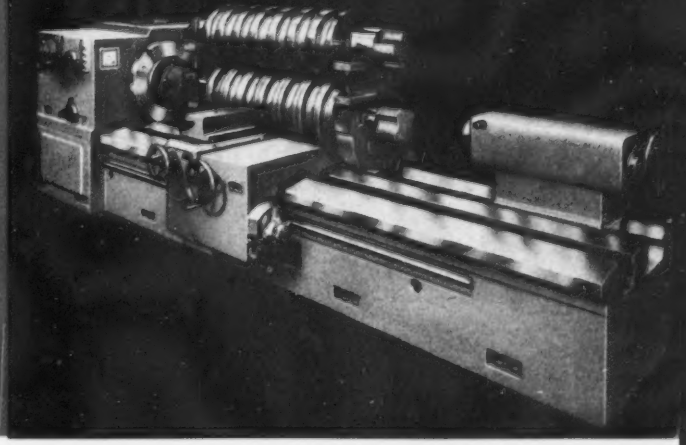

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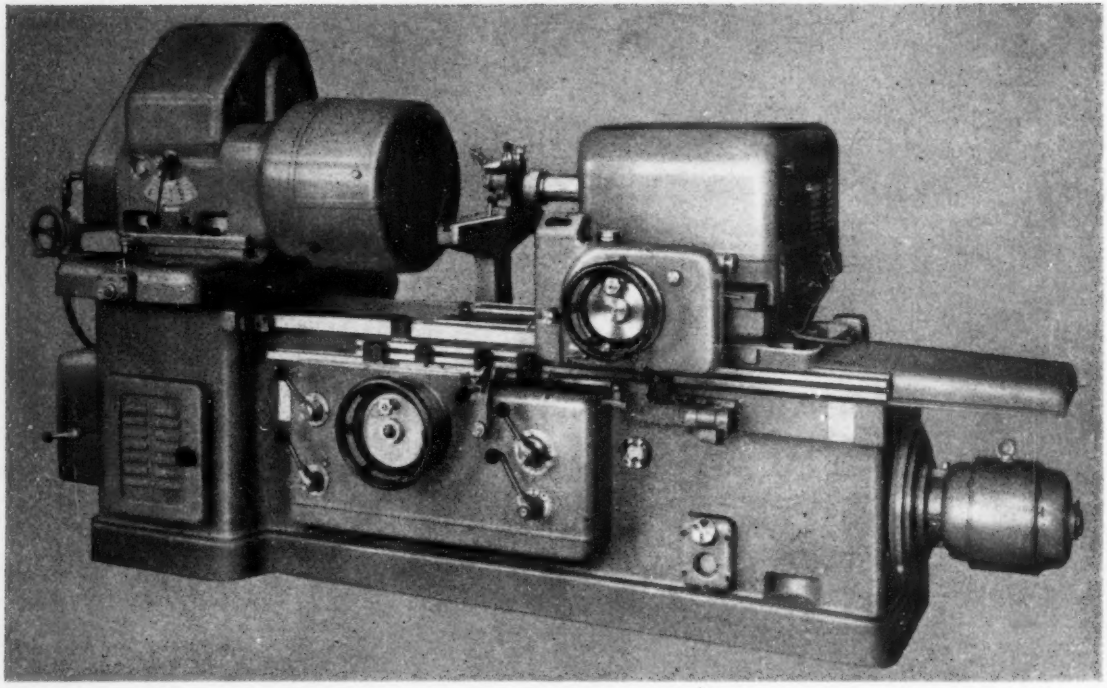

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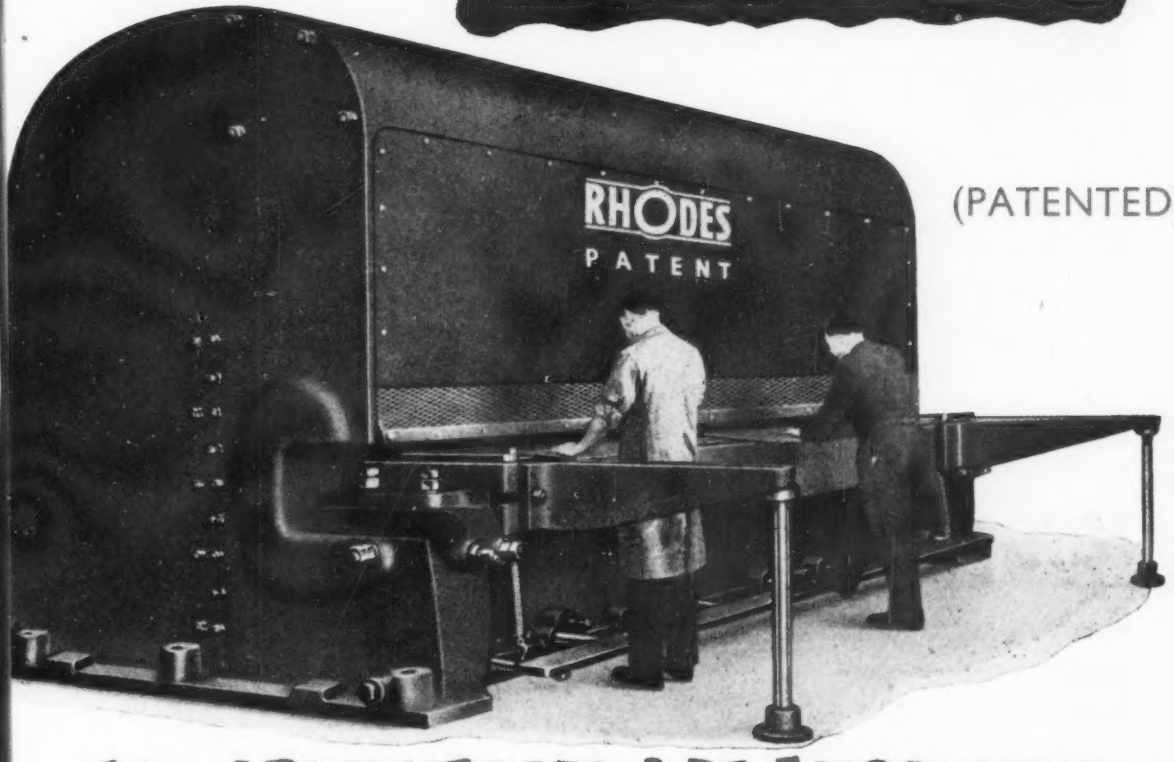

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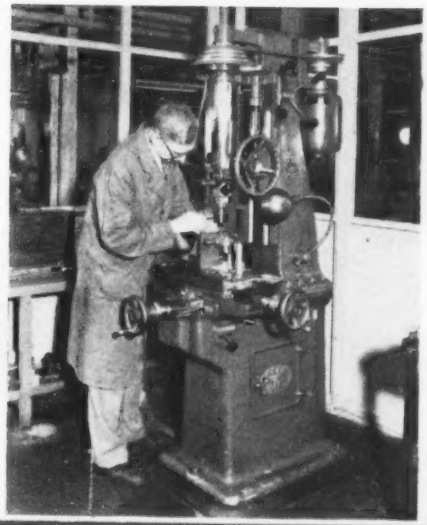

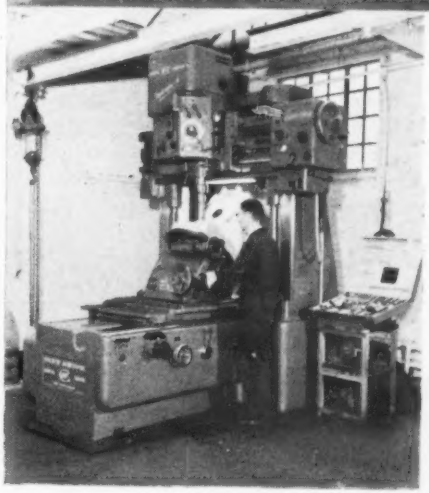

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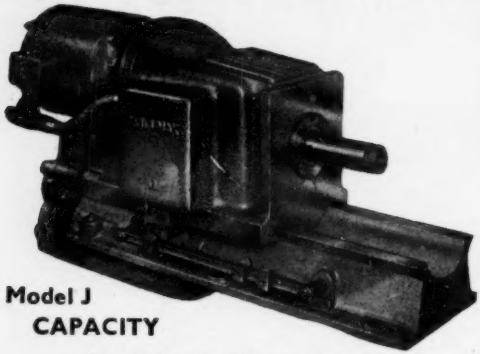

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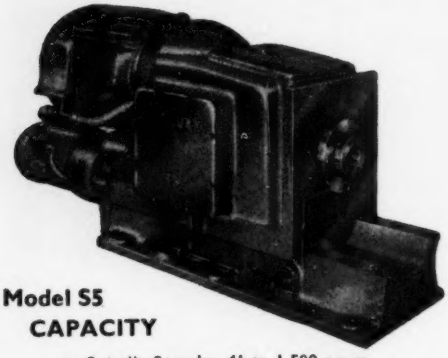

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CAPACITY

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Model S15

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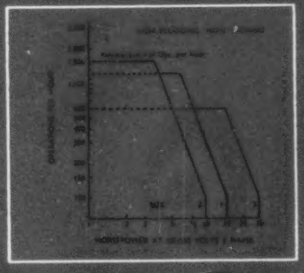

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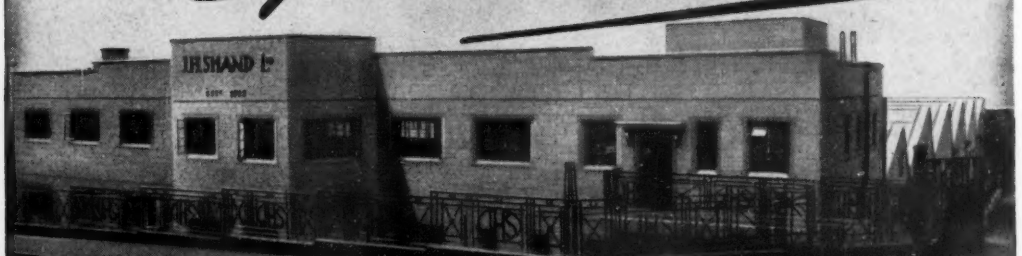

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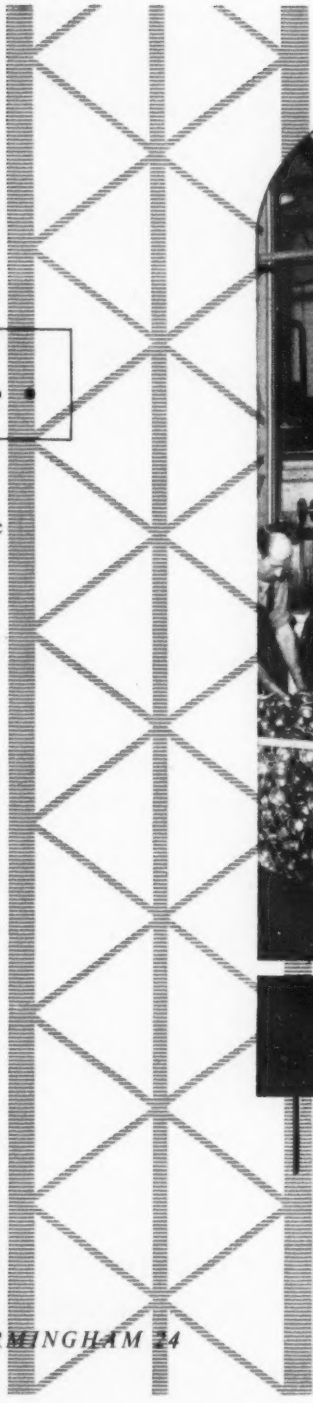

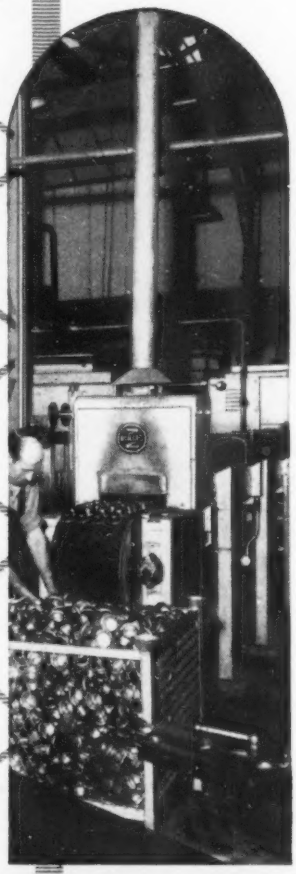

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Abstracts of Principal Articles

Production of Cash Registers and Accounting Machines ..... P. 804

In this article, the second devoted to the work of the National Cash Register Co. (Mfg.), Ltd., Dundee, attention is drawn to an automatic end-milling machine for finishing four faces on an accumulator gear, at a rate of 200 parts per hour. Machining operations on carriage stops are next considered, and it may be noted that a range of these parts are made from one type of blank. Cam and profile milling operations are then discussed, with particular reference to C.V.A. and Sundstrand machines, which have been specially developed for this type of work. Special checking gauges, which incorporate dial indicators, are also described. Details are given of an automatic set-up for reaming holes to close tolerances, the equipment comprising a bench drilling machine, with an air-hydraulic feed unit, and a pneumatically-indexed table. Other set-ups on bench drilling machines make use of air operated collets and chucks for holding the work. Reference is also made to high-speed milling operations, and to selective hardening and copper brazing operations for which specialized equipment has been installed. (MACHINERY, 93—8/10/58.)

Producing Electrical Components on Variomatic Machines ..... P. 815

Two Variomatic drilling, tapping and milling machines have been supplied for operations on small electrical components. One machine is arranged for the automatic production of plug pins from coiled brass wire, which is fed through a roller straightening unit, into cam-controlled jigs on the machine table. The required length is cut off and is indexed through successive stages, at which one end is reduced in diameter; a hole is drilled; the small end is machined to a domed form; a cross-hole is drilled; the reduced diameter is finish machined; the crosshole- is tapped; a slot is milled; and a locking screw is inserted and run home. The second machine carries out secondary operations on previously turned terminal sleeves. It is fitted with a vibratory bowl feeder and the operations performed consist of drilling, cutting two two transverse slots, and tapping. (MACHINERY, 93—8/10/58.)

Operations on Components for Missile Guiding Equipment ..... P. 818

Unusual techniques, close-tolerance machining, and special equipment are required for the production of the parts incorporated in the "AChiever" inertial-guidance system for directing missiles, which is undertaken at the new AC Spark Plug factory at Oak Creek, Wisconsin, U.S.A. Small pivots are rough machined on Tornos Swiss-type automatics, and after hardening and electro-chemical cleaning, these parts are finished on a Hauser pivot-burnishing machine. The pivot portion is first semi-finished with a ceramic wheel, and then finished with a tungsten-carbide wheel. Precision-boring of the aluminium-alloy gimbals is performed on a battery of six Heald Bore-Matics. The twin-heads on these machines are aligned to within 0·00005 in. and are maintained at a stable temperature within 2 deg. F. by means of electrical resistance heaters. A Barber-Colman hobbing machine is used to cut fine-pitch gears, and a typical specification requires a tooth-to-tooth composite error of only 0·0003 in., and a concentricity of the pitch circle with the integral shaft within 0·0005 in. total indicator reading. (MACHINERY, 93—8/10/58.)

Friction and Lubrication of Machine Tool Slideways ..... P. 824

A series of investigations is being carried out by P.E.R.A. in order to provide data for the design of machine tool slideways, and the first part of this work is considered in this article. After a brief discussion of terminology, the special test equipment that has been built is described. Numerous graphs are included relating to the results obtained from the test programme, and the effects of various factors on kinetic friction are discussed. (MACHINERY, 93—8/10/58.)

Cast-Master Automatic Loading and Unloading Unit for Die Casting Machines P. 839

The unit here described has been developed for use with single- or multiple-impression dies where inserts must be positioned in the cavities. One application is for casting the end rings and pole pieces of small electric motors in a 4-cavity die. Lamination stacks for these rotors are assembled on split tubular dowels, and are loaded into the unit during the casting cycle. When the metal in the cavities has solidified, the loading unit is advanced between the dies, and an ejector mechanism is operated to transfer the stacks to the fixed die. Next, the completed castings are ejected from the moving die into holders on the opposite side of the unit. At this stage the sprue and runners are clipped from the castings, and fall clear. (MACHINERY, 93—8/10/58.)

Large Extrusion Press Rams Reconditioned by the Master-Hone Process ..... P. 843

Master-Hone equipment has been effectively employed for reconditioning the main and return rams for a 2,500-ton hydraulic extrusion press. The main ram has diameters of 45 and 19½ in. and the length of each portion is 9 ft. 4 in. To restore roundness and parallelism, a total of 0·024 in. was removed from the larger portion, and 0·075 in. from the smaller. It was specified that the honed surfaces should be concentric. After the 20-in. diameter by 12-ft. long piercer ram had been reconditioned, it was possible to push a bronze ring, of 0·001 in. larger bore diameter from one end to the other without appreciable variation of resistance. (MACHINERY, 93—8/10/58.)

Safety in Die Casting

Reductions in the number and severity of personal accidents in factories from all causes are, of course, highly desirable on humanitarian grounds. Quite apart from this aspect, however, the effects of accidents—and particularly those of a serious nature—on production may be far-reaching, so that the provision of reliable safety equipment is also fully justified from the economic standpoint. Loss of the services of a trained operator for a period, and the fact that a machine may stand idle while arrangements are made for a substitute, may result in only comparatively minor dislocation. Of much greater significance may be the psychological influences on others working in the same department. If it serves as a deterrent to dangerous practices which have been adopted, the aftermath of an accident may in some respects be salutary, but it is quite probable that unnecessary care may be taken for a time with consequent disturbance of established rhythm, and both the quantity and quality of output may then be considerably affected.

The Annual Report of the Chief Inspector of Factories, for 1957, shows a welcome fall in the total number of accidents in factories to 150,437 as compared with 160,116 in the previous year. For the purpose of these statistics, it may be noted, a recorded accident is one which disables a person for more than three days from earning full wages at the work at which he or she was employed. The general reduction in injuries, however, is no justification for complacency, and continual vigilance must be observed to secure further improvements, particularly in certain fields. Of the total number of factory accidents in 1957, 23,793 were caused by power driven machinery, and when various classes of machinery are considered separately it is found that there were increases for—among others—power presses and planing machines.

Separate figures are not given for die casting machines, which in some respects resemble presses, but it is evident, in view of their special characteristics, and the increasing use of larger units with higher operating pressures, that greater attention to safety arrangements is frequently desirable. These machines, indeed, receive special mention in the Report, and it is pointed out that the associated problems have been under consideration by a Safety Committee of the Zinc Alloy Die Casters' Association. A report containing various recommendations has been issued to the industry by this committee, and the subject will be examined in some detail in an article to be published in MACHINERY in the near future.

Here, it may be noted that the main risks encountered in the die casting shop are of burns caused by molten metal escaping under pressure from the dies, and of the crushing of hands or other parts of the body between the dies or platens, on account of accidental closing. Molten metal, it is stated, is responsible for some 60 per cent of the accidents which occur, but injuries caused by trapping, although less numerous, are usually much more serious.

Basically a die casting machine is of very simple design, and although provision for an automatic cycle, including power movement of core slides, may involve considerable complication, it might nevertheless appear, at first sight, that effective safety arrangements could be applied with little difficulty. In practice, however, it is found that although a fairly satisfactory degree of protection can often be afforded by comparatively elementary guarding systems, virtually complete safety is by no means easy to achieve. It is considered, for example, that, regardless of such interlocking precautions as may be taken, assurance that dies will never close inadvertently can frequently only be afforded by introducing the principle of positive mechanical restraint. For this purpose a strut, reminiscent of those employed on power presses to prevent accidental descent of the ram when work is being carried out on the tools, is interposed between the platen faces when the dies are open. Such a strut must be capable of withstanding the closing force without buckling, and it should preferably be brought into position automatically, for example, by the action of opening a guard. Even if such an automatic arrangement is not considered necessary, however, it is a simple matter to provide a strut which can be moved into position manually to enable die adjustment or changing to be carried out in safety.

Either as an alternative or in conjunction with a strut arrangement, an exhaust valve may be provided which ensures that pressure cannot build up in the die closing cylinder unless the guard is shut. Such a system may not be wholly effective for a direct hydraulic machine, but with the more usual cylinder and toggle mechanism it will prevent the dies from coming together again should

(*Continued on page* 859)

Production of Cash Registers and Accounting Machines

Methods Employed by the National Cash Register Co. (Mfg.), Ltd., Dundee

An article published in MACHINERY, 93/692-24/9/58, described some of the methods employed in the manufacture of cash registers, accounting machines and adding machines in the modern and well-equipped factories of the National Cash Register Co. (Mfg.), Ltd., at Dundee, where some 3,000 people are now employed. Accounting and adding machines incorporating different features are made to cover a wide field, and there are three types of cash register, two of which are electrically operated. One of the latter, known as the Class 21, which had recently gone into production, is shown in the heading illustration.

Attention has been drawn to the production planning and tooling problems presented by reason of the large number of components required in the types of products which the company makes, an accounting machine, for example, containing up to 15,000 parts. There are approximately 2,200 parts in the Class 21 cash register for which some 5,000 press tools, jigs, fixtures and gauges are needed. Thus, although the output of finished units from the assembly lines is considerable, and a total of 3,000,000 component parts is manufactured each week, the number of different batches involved necessitates the use of tooling set-ups which are adaptable, or can be rapidly changed, while ensuring economic production times together with a high degree of precision.

Reference has been made to the production of various long shaft components on Brown & Sharpe automatics specially adapted for the purpose, and to set-ups on Cincinnati machines for broaching peripheral serrations in pressed steel cams, and side slots in stainless steel carriage stop bars. An interesting conversion of a Townsend riveting machine to provide for automatic operation with dial feed has also been described, and attention was drawn to the extensive use which the company makes of Roto-Finish barrelling equipment. Details are given here of some other efficient set-ups.

AUTOMATIC END-MILLING MACHINE

Fig. 1 shows a special-purpose machine which has been designed for finishing, with tungsten-carbide tipped end mills, the four faces associated with the 0·1527-in. dimensions on the part shown in Fig. 2. This component, known as an accumulator gear, is used in the National Class 31 accounting machine and it comprises a mild steel hub to which are copper brazed a mild steel, 20-tooth, hobbed gear, and an oval pressing, the latter being finished machined on the two tips after the brazing operation. Prior to assembly and brazing, these tip portions are semi-finished by hobbing, with the blanks stacked on a mandrel. The pressed gear blank is serrated, planished to ensure flatness, and after assembly the outside diameter of the gear teeth must be concentric with the bore of the hub within 0·002 in. total indicator reading. For this reason, a hob which tops the blank is employed for cutting the teeth.

Before the tips are finish machined, removing 0·003/0·005 in. from each face, the centre hole in the hub is reamed to 0·158 in. diameter, and the

assembly is then carburized, and cleaned by vapour blasting. Hardening is carried out after the tips have been precision milled.

Referring to Fig. 1, the milling operation is performed on the two sides of a tip simultaneously, using ¼-in. diameter, 4-tooth end mills carried in high-speed spindle quills *A* and *B* of a design developed by Precise Products Corporation, Racine, Wisconsin, U.S.A., which are operated directly from the 50-cycle electrical supply, and run at a speed of 45,000 r.p.m. The quills are clamped in brackets, as at *C*, carried, in turn, on compound slide units *D*, which are secured at the required angles on the machine base, and provide for hand adjustments for setting the cutters.

The workpiece, seen at *E*, is located by the reamed hub bore on a stud in the table *F*, and it is aligned angularly by means of a pivoted pawl *G*, which engages a selected tooth space of the gear. A pinion *H*, at the front, meshes with the gear, and provides for automatic indexing through 180 deg., after the first tip has been milled. Vertical feed of the table unit during the milling operation is effected by an air cylinder *J*, and the work is clamped vertically by contact with a pad on the piston rod of an oil dashpot, *K*.

The automatic cycle is initiated by two-handed

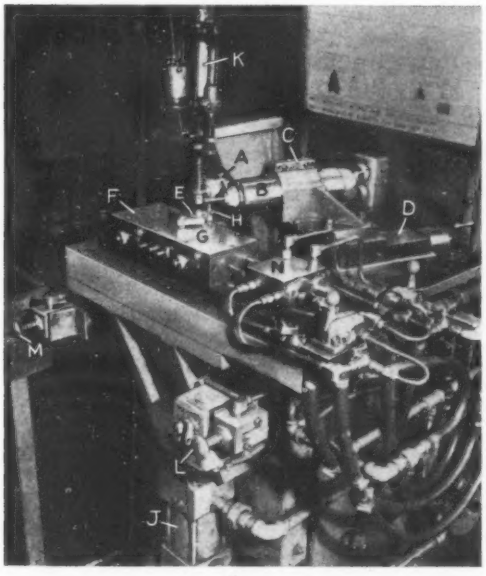


Fig. 1. Automatic machine incorporating "Precise" electric high-speed spindle heads for milling two faces simultaneously on accumulator gears, with tungsten carbide cutters

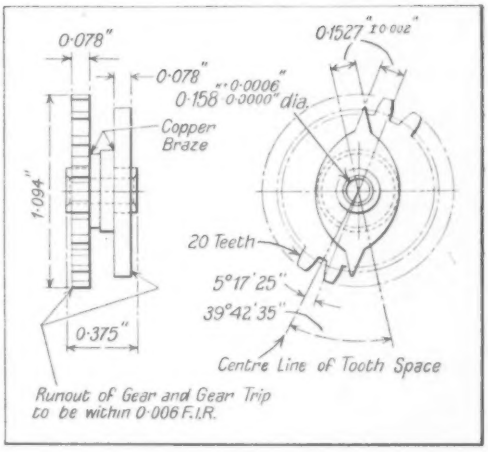


Fig. 2. Details of the accumulator gear which is milled on the machine shown in Fig. 1

operation—for safety purposes—of the push-button air valves *L* and *M*, and when the table has been retracted downwards, after the first tip has been milled, the pawl *G* is disengaged, and the work is indexed, by the admission of air to the duplex cylinder block *N*. The two piston rods of the latter operate the pawl and index mechanism, through racks and pinions, and the return motion of the index gear is made after disengagement of the pawl at the end of the cycle, to allow the work to be unloaded. An output of 200 pieces per hour is obtained from this machine.

"Precise" spindle quills, it may be noted, are available in a range of sizes and are sold in this country by Lorant & Co., Ltd., 98-100, Croydon Road, London, S.E.20. The quills fitted to the machine described are designated Super 50, and the driving motors develop ¼ h.p. Of the same overall size, the Super 60 quill incorporates a ½ h.p. motor, and, in addition to smaller units, the range includes the Super 80, of 1½ h.p. which has a 3¾-in. diameter body and an overall length of 15½ in. A separate electrical control unit enables the spindle speed to be varied from 7,000 to 25,000 r.p.m., and a filter unit is incorporated in the quill for cleaning the cooling air for the motor windings and the high-precision ball bearings in which the spindle is mounted.

The accessories available include various types of mounting brackets and stands, and speed control units for the smaller types of quills. Small precision milling machines incorporating these quills are also made, and can be supplied with hand or

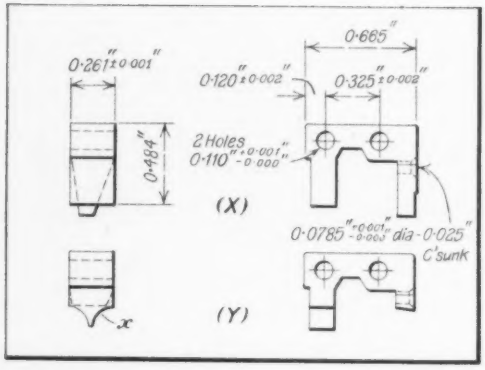


Fig. 3. The mild-steel blank shown at *X* serves for several types of carriage stop blocks, one of which is seen at *Y*

air-hydraulic feed for the table. Certain types of these Precise high-speed quills are also being made in Germany.

MACHINING OPERATIONS ON CARRIAGE STOPS

In the previous article, reference was made to a stainless-steel stop bar, approximately 32 in. long, with broached slots in each side, which is incorporated in the carriage of the National Class 31 accounting machine. The adjustable stops fitted to this bar are made from rectangular, cold-drawn mild-steel stock, and blanks, as shown at *X* in Fig. 3, are first produced by gang milling and cutting-off operations. The blanks are de-burred in a Roto-Finish barrel, and, after the holes have been drilled and reamed, the parts are copper plated to provide for masking during subsequent case-hardening. This steel blank serves for several types of stops, one of which is shown at *Y* in Fig. 3. The milling operations performed at this second stage remove the copper plating, so that only the two tips of the stop are case hardened.

The 0·0785-in. diameter hole in the end of the blank is drilled and reamed separately, and for the two 0·110-in. diameter holes, an automatic drilling and reaming machine, shown in Fig. 4, has been built by the company. This machine incorporates four Maxam air-driven spindle heads, as at *A*, and the construction has been further facilitated by the use of a standard Centec (Central Tool & Equipment Co., Ltd.) air-operated indexing table *B*, which is fitted with a top plate *C* carrying eight fixture stations for the work.

Because of the relatively large diameter of the fixture plate, additional location at the index positions is provided by bushes *D* in the plate, which are engaged by a plunger on the piston rod of the air cylinder *E*. Any swarf that has accumulated in the bushes is blown out by an overhead air jet at each indexing motion of the table. The table indexes in a clockwise direction and it may be noted that it is here shown out of the index position. A nest location is provided for the workpiece in the fixture, and clamping is effected by a spring-loaded end pad, which is carried on two round guide bars coupled together by a bridge piece. The latter carries a roller *F* which rides over a fixed cam track at *G*, supported on pillars on the base, so that the clamp is released when the particular fixture reaches the index position beneath the overhead chute *H*. A jet of exhaust air from beneath the fixture then ejects the finished piece, by way of the chute, into a container on the right of the machine. The cam rise is extended to hold back the fixture clamp at the next index position, at which a fresh workpiece is loaded.

The four Maxam spindle heads are attached to upper and lower blocks clamped to round pillars, as at *J*, whereon are also mounted blocks *K*, provided with tenon grooves in the top surfaces to accommodate bush plates for the two drills and the two reamers. Accurate positioning of the bushes in relation to the work can thus be effected by adjusting the blocks *K* about the pillars, and moving the plates along the tenon grooves. No

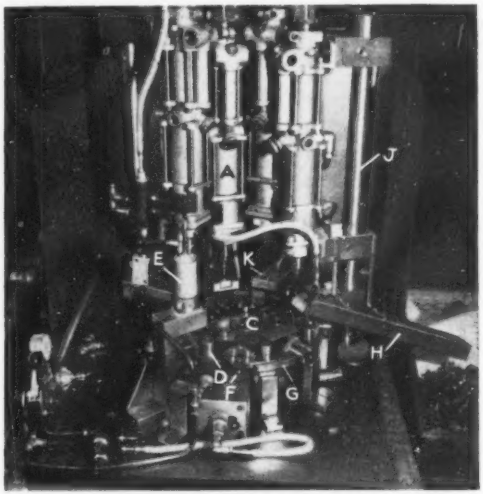


Fig. 4. Automatic air-operated drilling and reaming machine for carriage stops, incorporating Maxam spindle heads and a Centec indexing table

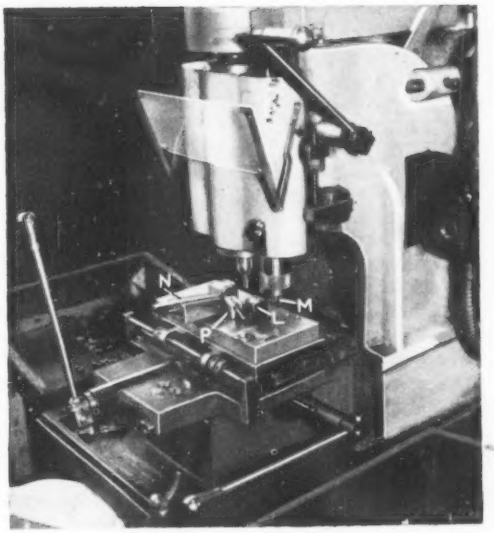


Fig. 5. Set-up on a C.V.A. hand-controlled profile milling machine for producing the contour *x* on the carriage stop seen at *Y* in Fig. 3

coolant is employed on this machine, and the cycle of 9 sec. affords ample time for loading the workpieces by hand.

CAM AND PROFILE MILLING

The curved form at *x* on the carriage stop seen in Fig. 3 is produced on a hand-operated profile milling machine which was built to meet the company's requirements by C.V.A. Jigs, Moulds and Tools, Ltd., and the set-up is shown in Fig. 5. These machines, of which several are installed, are found to afford a simple and economical means of handling a variety of the small, profiled parts required in cash registers and accounting and adding machines. The machine table is moved longitudinally and transversely, through racks and pinions, by means of hand levers which can be adjusted for angle on the pinion shafts to the most convenient operating positions.

To control the profile produced on the work, a hardened steel master, of 1 to 1 ratio, is mounted at *L* in the work fixture and is engaged by a stylus pin *M* carried on the cutter head. The stylus pin and master are slightly tapered, and adjustment for cutting size can thus be obtained by raising or lowering the spindle head. In the set-up shown, a standard high-speed steel end mill of $\frac{5}{16}$ in. diameter is used, and the workpiece is held in the fixture by a screw-operated clamp *N*, and a cam clamp *P* mounted in a pivoted block so that it can be swung clear for loading and unloading. The output obtained is 200 pieces per hour.

A tolerance of 0·002 in. is specified for the milled form, and the gauge provided for checking the workpiece is shown in Fig. 6. It incorporates two dial indicators *R* and *S*, reading to 0·0001 in., which are mounted on fixed holders provided with hardened-steel datum inserts at the front, as at *T*, directly below the dial gauge stems. The workpiece is held by two clamps in a fixture block *U*, which can be moved freely on the machined top surface of the gauge base, the piece being located at the same height as the dial gauge stems. Fixed immediately below the work, and in the correct relative position, is a hardened-steel, profiled master *V*, of 1 to 1 ratio, which is located in line with the datum inserts *T* of the dial gauges.

The dial gauges are set to zero with the aid of a hardened and ground steel block which rests on the base and is held in contact with the datum inserts and the gauge anvils. A direct reading of any error on the workpiece is thus obtained as the master *V* is moved round the datum insert. The insert for the gauge *R* has a radiused end, for checking the curved profile of the part, and that for the gauge *S* has a flat end face and is employed for checking the extreme tip. A gauge of similar design, it may be noted, is provided for checking the form of the accumulator gear component which is milled with tungsten-carbide cutters on the machine shown in Fig. 1.

For handling certain larger profiled workpieces,

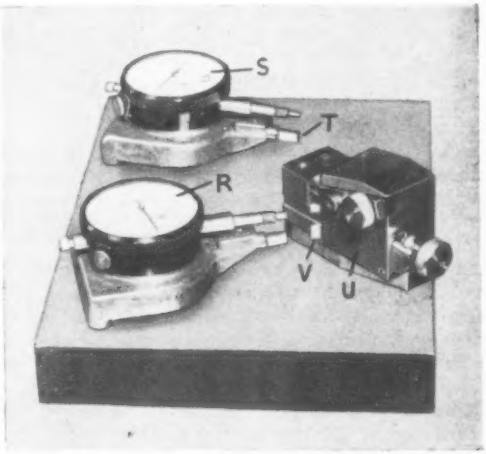


Fig. 6. Gauge incorporating two dial indicators for checking the milled profile of the carriage stop

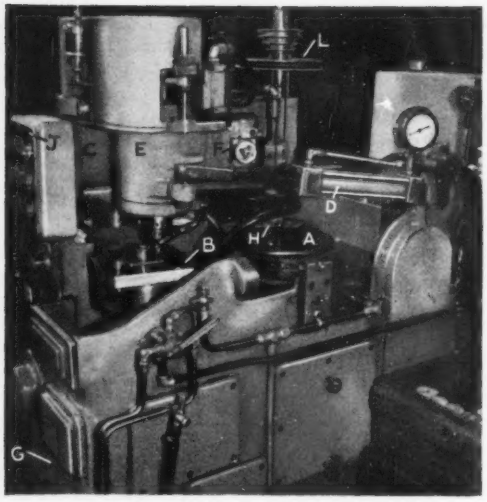


Fig. 7. A Sundstrand contour milling machine which is employed for the production of a variety of cams and other components

and for producing a variety of plate cams, the company has installed an American-built Sundstrand automatic contour milling machine, which is seen in Fig. 7 set up for milling the cam shown in the drawing Fig. 8. This component is blanked from 0·078/0·080-in. thick mild steel, and prior to the cam milling operation, which removes 0·015/0·020 in. from the form, the piece is copper plated so that only the profile is later carburized and hardened. Cam profiles are also finished by shaving where the size of the batch quantity produced justifies the cost of a tool, and, here again, the parts are first copper plated if local hardening is required.

On the Sundstrand machine, the profile is produced under the control of a 2 to 1 ratio master, *A*, Fig. 7, which can be made with a considerably larger base-circle diameter than the workpiece, if desired, steep rises being thus avoided. The master is rotated in unison with the work-table *B*, and is engaged by a follower carried in the spindle arm *C*, the latter being arranged to pivot on a sleeve which has 4¾ in. of vertical adjustment on a substantial round column. Firm contact of the follower with the master cam is maintained by hydraulic pressure in a cylinder *D*. This cylinder is pivoted at the rear on the machine frame, and the piston rod is coupled by a link to the spindle head *E*. The head is mounted in trunnion bearings on the arm, and can be adjusted angularly in relation to the cam follower by means of a screw and graduated collar at *F*, for setting the cutting size on the work.

Drive to the work-table and the spindle carrying the master cam is taken from a hydraulic motor which normally provides steplessly-variable speeds from 0·2 to 3·25 r.p.m., and a rapid return speed of 23 r.p.m. If required, the machine can be supplied with speeds from 0·4 to 6·5 r.p.m., and a rapid return speed of 46 r.p.m. The work-table mounting is of 6 in. diameter, and the maximum diameter that can be contour milled is approximately 5 in.

Steplessly-variable speeds from 400 to 3,500 r.p.m. are available for the cutter spindle, the drive being taken by way of a shaft and V-belts from a ¾-h.p. motorized variable-speed unit at the foot of the spindle head column. The cutter spindle is quill mounted, and a vertical hydraulic feed, up to a maximum of 1¼ in., is available, which can be controlled by dogs and micro-switches to provide automatic cycles of rapid approach, feed and rapid return.

Rotation of the work-table, through any angle up to 480 deg. (1⅓ rev.), in-feed, and rapid traverse, both forward and reverse, are controlled by adjustable dogs on a drum which is accessible from the front of the machine, through a door at *G*. If required, the table can be arranged to dwell against positive stops at the starting and finishing positions. The dogs on the drum also control the cylinder *D* which advances and retracts the arm *C* carrying the cutter head and master cam follower.

For milling plate cams, when the start-cycle button is depressed the arm swings rapidly towards the cutting position and the operating lever of a micro-switch makes contact with the master cam a short distance in advance of the follower. Operation of this micro-switch starts the rotation of the work-table and also reduces the speed of the arm movement while the cutter feeds into the work and the follower comes into contact with the master cam.

When milling internal cams, the automatic cycle of the spindle quill is brought into operation to traverse the cutter vertically into, and out of, the work. Various sequences of rotary table movement, vertical quill traverse, and advance and return motions of the cutter head arm can be obtained by means of selector switches on the control panel *J*, so that different types of workpieces can readily be milled with completely automatic cycles. The motions can also be controlled independently for setting-up purposes, if required.

Facilities are provided on the machine for producing enlarged-diameter master cams from a

sample workpieces by reversing the milling process, and a considerable amount of toolroom time can thus be saved. For this purpose, the cutter is replaced by a parallel, hardened and ground steel pin of appropriate diameter, which engages the sample piece on the work-table, and a cutter is inserted in the follower spindle.

The latter is quill mounted and carries a V-belt pulley *L*, which enabes the drive to be taken from the main cutter spindle. When carrying out this operation, the piston of the hydraulic cylinder *D* is disconnected from the cutter head, and the arm is controlled manually.

Cams of the form shown in Fig. 8 are milled six at a time. They are clamped by a nut on a shouldered mandrel, and for angular location a pin engages a ¼-in. diameter reamed hole, provided for this purpose in each blank. The mandrel, which is arranged to slide vertically, is coupled to an air cylinder below, and after the clamping nut has been removed, it can readily be stripped from the finished pieces, and then returned upwards to the loading position.

The operation is carried out with a Clarkson high-speed steel, spiral-tooth cutter of ½-in. nominal diameter, which is securely held in a chuck, and a range of follower rollers, in diameter steps of 0·020 in., from a nominal of 1½ in., is provided for use as the cutter diameter is reduced by sharpening. Of cast iron, the master cam is ¼ in. thick. An output of 50 pieces per hour is obtained

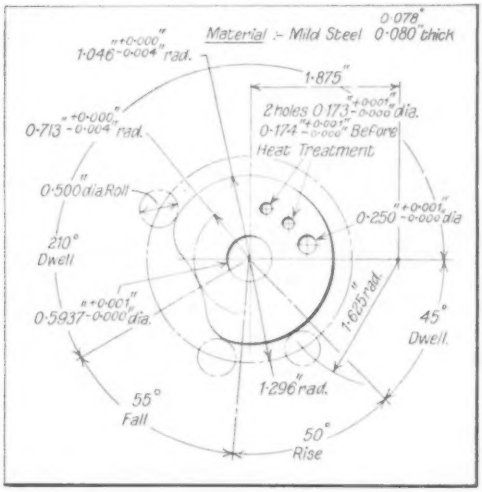


Fig. 8. Details of the pressed steel cam which is being produced, six at a time, on the Sundstrand profile milling machine

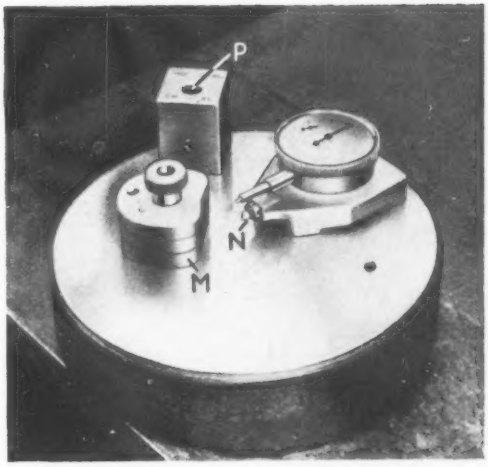


Fig. 9. Dial indicator gauge provided for checking cam profiles produced on the Sundstrand machine

from this set-up, and a high surface finish can be maintained on the work profile.

The indicator gauge seen in Fig. 9, employed for checking the cam profile, is generally similar to that shown in Fig. 6, for the carriage stop block component. Only one dial gauge mounting, however, is necessary in this instance. The part to be checked is located by the bore and the ¼-in. diameter reamed hole, directly on the master cam *M*, whereon it is clamped by a knurled nut, and the master is engaged by a radiused stylus *N*. For setting the dial gauge to zero, the hardened and ground steel block *P* is applied to the stylus and the gauge anvil. This gauge, with suitable work holders, serves for a range of cams, and 31 different parts are milled on the Sundstrand machine.

AUTOMATIC SET-UP FOR REAMING

Holes to close tolerances are specified for a wide variety of components used in cash registers and accounting and adding machines, and where the required reaming operation must be performed separately, the equipment employed includes several Kerry sensitive bench drilling machines which have been provided with Pacera-Maxam air-hydraulic feed units and various aids to work handling.

One of these machines, seen in Fig. 10, is arranged for continuous automatic operation by the provision of a Centec pneumatic indexing table *R*, carrying a 12-station fixture plate fitted with

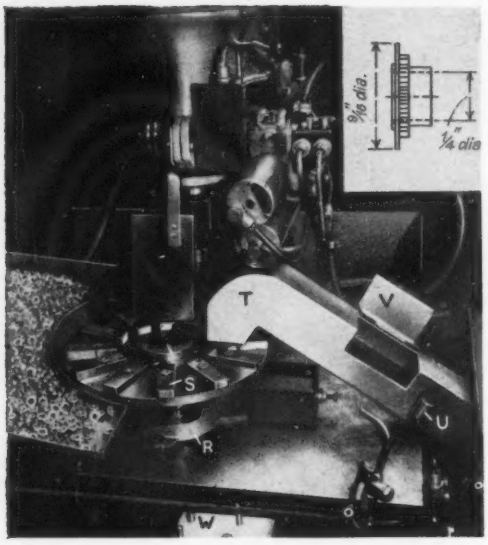


Fig. 10. Adaptation of a bench drilling machine to automatic air operation for reaming and tapping. A Pacera-Maxam air-hydraulic feed unit and a Centec indexing table are employed

V-jaws for holding round workpieces. Each part is placed by hand between a sliding outer jaw S, and a fixed inner jaw, the sliding jaw being held open by a light spring. At the reaming position, pressure is applied to the outer jaw, to clamp the workpiece, by means of a pad mounted on the piston of an air cylinder secured to the table at the rear. As the table indexes in a clockwise direction, the finished pieces are ejected automatically by an air jet, from below, into a chute *T*, leading to a container. A sliding baffle plate is provided at *U*, also a hinged lid *V*, so that sample workpieces can be collected periodically from the chute for checking, by the operator, on plug gauges *W*, fixed at the front of the machine. If the samples are found to be correct, the baffle plate is withdrawn to allow the batch to fall into the container. With this arrangement, the risk of producing scrap is minimized and it is ensured that virtually all the parts delivered to the container are within the gauge tolerance.

The valve which controls the air clamping cylinder is operated, at the appropriate point in the automatic cycle, by a cam mounted on the end of the rack pinion shaft of the spindle quill, and valves, on the right, control the air-hydraulic feed unit and the indexing table. The fixture plate shown will accommodate work up to ½ in. diameter, and another, interchangeable, plate is provided for holding parts up to ¾ in. diameter.

Attention is drawn to the improved results that are obtained at this type of reaming operation by the use of a standard floating holder for the reamer, as employed on an automatic screw machine, the ⅜-in. diameter shank of the holder being reduced to ½ in. to suit a conventional drill chuck.

The component which is being reamed is shown inset in Fig. 10. It comprises a steel pinion, to which a $\frac{9}{16}$-in. diameter pressed steel shroud washer is assembled by spinning, and prior to this operation the two parts are zinc plated. The hole is reamed ¼ in. diameter, with a standard high-speed steel reamer, and an output of 1,000 pieces per hour is obtained. The machine is also readily adaptable to tapping operations, for which purpose an American-made Procunier No. 1 (Henry Challis, Ltd.) tapping head of $\frac{3}{16}$-in. capacity, or a Swedish S.P.V. type SAR/OA (John Harris Tools, Ltd.) tapping head is employed. Reference may also be made to the use of Wahlstrom quick-change chucks and to the application of coolant by Norgen oil mist units on sensitive drilling machines. Slack & Parr multiple spindle heads afford another means of reducing production costs for drilling operations.

Fig. 11 shows an application of a Pacera-Maxam air-hydraulic feed unit on a Kerry machine set up

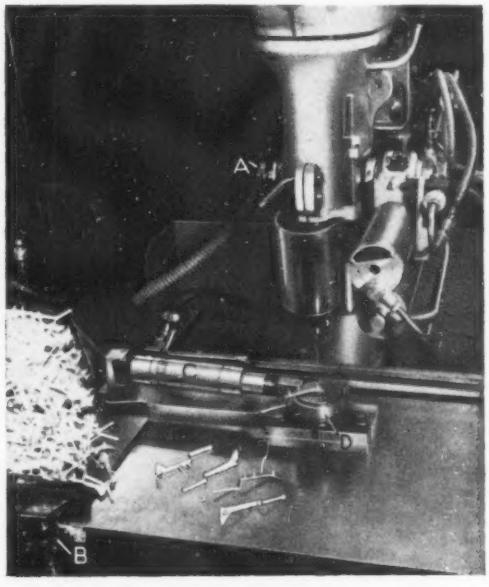


Fig. 11. Another application of Pacera-Maxam feed unit on a bench drilling machine

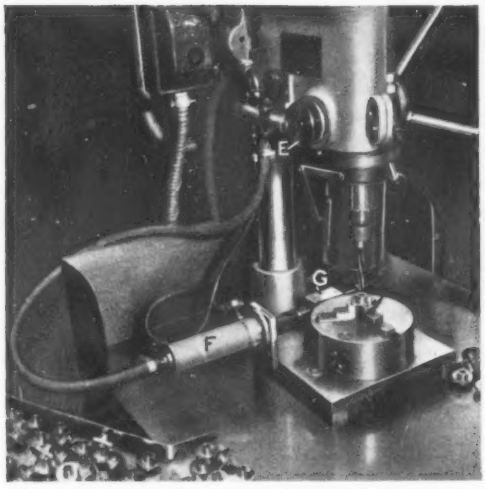


Fig. 12. An application, on a bench drilling machine, of a standard 3-jaw scroll chuck adapted to air operation under cam control

for reaming a hole in a brazed assembly, the reamer, again, being mounted in a floating holder. The work is held in an air-operated collet fixture, which is employed for a variety of other jobs, and is opened and closed, automatically, under the control of a valve operating cam *A* on the rack pinion shaft. For safety purposes, the cycle is initiated by right- and left-hand push-button air valves, as at *B*. The collet operating cylinder *C* is trunnion mounted at the rear, and the piston rod is coupled, by means of a yoke and pivot pin, to the threaded cap *D*, which opens and closes the collet. Provision is also made on this fixture for ejecting the workpiece by an air jet, from below. The stop rails fitted at the rear of the table serve for locating jigs for other operations.

A standard Pratt 6-in. 3-jaw scroll chuck has also been adapted with good results to air operation, as shown in Fig. 12, where it is being used in connection with a reaming set-up on one of the Kerry machines. Feed, in this instance, is applied by hand, and the chuck is opened and closed automatically during the quill movement, under the control of a valve actuated by the cam *E* on the rack pinion shaft. The piston of the Maxam air cylinder *F* is coupled to a rack, which slides in the block *G* and meshes with a pinion shaft provided with a square end to engage the chuck socket. This pinion shaft is held in position axially by means of a spring, so that it can readily be disengaged to enable the chuck jaws to be adjusted to suit the diameter of the workpiece. A sheet metal guard, which has been removed to enable the arrangement to be seen more clearly, protects the mechanism from swarf.

HIGH-SPEED MILLING OPERATIONS

The milling operations required on components for cash registers, accounting and adding machines are essentially of a light nature, and special attention has been paid to the selection of the most suitable types of machine tools for this purpose. The equipment installed include Adcock & Shipley No. 1 horizontal milling machines, also U.S. Multimill machines, some of which were modified by the company about a year ago to provide air-hydraulic feed for the table, in conjunction with air-operated fixtures, with the object of obtaining shorter cycle times.

More recently, three Adcock & Shipley No. 0 size, horizontal, automatic-cycle milling machines, with built-in air-hydraulic feed cylinders for the table, have been installed, one of which is shown in Fig. 13. This particular type of machine was introduced at the 1956 Machine Tool Exhibition at Olympia, specially to meet the requirements of light precision engineering and it operates on the

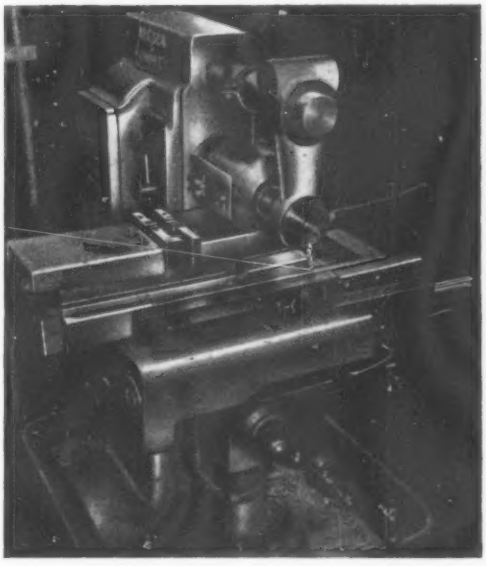


Fig. 13. Typical set-up on one of the Adcock & Shipley No. 0 air-hydraulic feed milling machines, which can perform very rapid automatic cycles

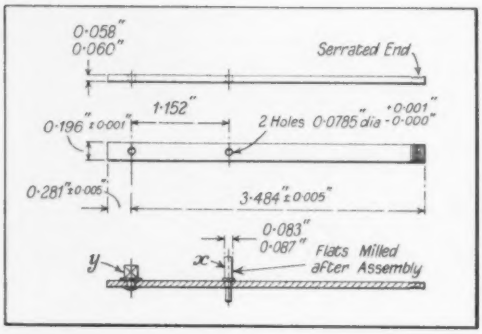


Fig. 14. Key stem component which is straddle milled with the set-up seen in Fig. 13

same general principle as the converted No. 1 machines at the Dundee factory. The table has a working surface of 12¼ by 5 in., and a maximum travel of 5¾ in., and a metering valve enables the rate of feed to be readily adjusted. Drive to the spindle is taken from a 1-h.p. motor, and the 12 speeds available normally range from 150 to 3,000 r.p.m. If required, speeds up to 4,000 r.p.m. can be provided, and it is stated that the machine can be operated with cycle times as short as 3½ sec.

With the set-up shown, 0·083/0·087 in. flats are straddle milled on the round stud assembled in the key stem seen in Fig. 14, which is required in a number of types, differing in length. Reference has been made to this component in the previous article, in connection with an automatic set-up on a Townsend riveter for assembling the two studs. For the milling operation, the part is held by special jaws in a vice operated by a Maxam air cylinder. The vice is closed automatically at the beginning of the cycle, and opened when the table has returned rapidly to the starting position. Because of the speed of the cycle, the control valve is arranged for two-handed operation, it being necessary to lift a safety lever before the start button can be depressed. Cutters of 3 in. diameter, with 16 Wimet tungsten-carbide tipped teeth, are run at 870 r.p.m., and an output of 400 pieces per hour can be maintained.

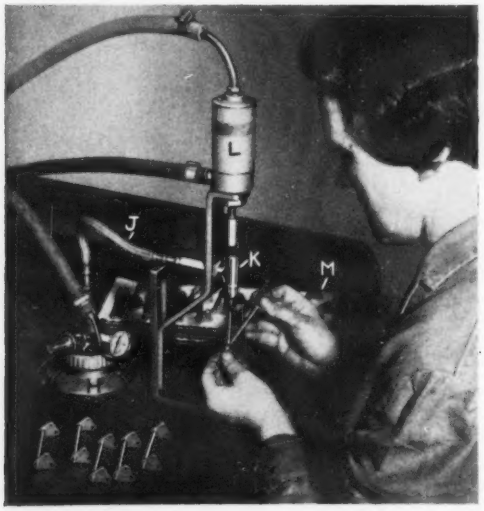


Fig. 15. Applying brazing paste, composed of copper powder suspended in oil, by means of a dispenser specially developed for the purpose

HARDENING AND BRAZING

As already mentioned, assembly by copper brazing is extensively employed, and for this purpose chain-belt conveyor furnaces by Birlec and Efco are installed, which are capable of handling, economically, a wide variety of components. The protective atmosphere is provided by burnt town gas.

The practice of using pre-formed rings of copper wire, which are placed on the work before it is loaded into the furnaces, has now been largely superseded by the application of copper-powder paste from dispensing units, as seen in Fig. 15, which have been developed by the company. This method offers particular advantages for assemblies where a copper wire ring is liable to become dislodged from the joint position, and it also permits economies in production times and ensures more uniform quality in the brazed joints.

Copper powder, suspended in turbine oil, is stored in a standard Bullows pressurized paint container *H*, air from the shop line serving to feed the paste, by way of a pipe *J*, to a metering piston valve *K*. The latter is operated by a Maxam air cylinder *L*, controlled by a foot valve, and the travel is adjusted so that, at each stroke, the required amount of paste is delivered through the nozzle on to the work. After the paste has been applied, the workpieces are loaded directly on to the brazing furnace tray, as at *M*, which is covered with a sheet of thin asbestos paper to provide a fairly level surface. This paper is discarded after each furnace cycle. A small, motor-driven, agitator is provided at the rear of the bench for stirring the copper paste periodically, to maintain the suspension.

For the National Cash Register range of

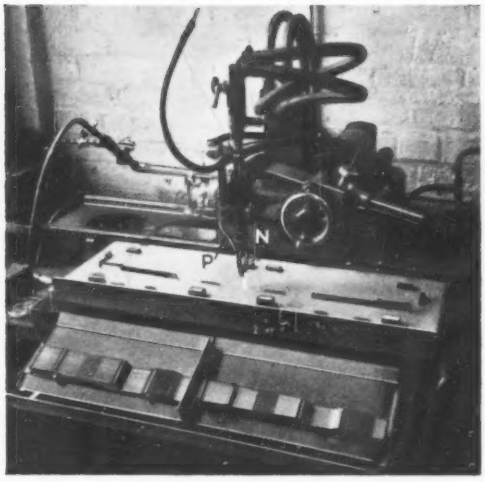


Fig. 16. B.O.C. flame hardening machine installed for locally hardening a variety of pressed components made from high carbon steel

Fig. 18. View of the Birlec induction heating equipment set up for locally hardening two pressed steel components simultaneously

machines, a variety of pressed parts is produced from high-carbon steel, and many of these parts must be hardened, locally, on ratchet and gear teeth, latch steps, cam slots and other surfaces. An automatic flame hardening machine, shown in Fig. 16, built by the British Oxygen Co., Ltd., is employed for this purpose. It is of the traversing burner head type, and the wheeled carriage *N* is driven by a variable-speed motor so that the traverse rate can be accurately adjusted to suit the work in hand.

In the illustration, the machine is arranged for handling the part shown in Fig. 17, which requires to be hardened on the teeth at *a*, *b* and *c*, and on the steps *d*. The four operations are performed separately, with the work clamped, by knurled screws, in a simple type of fixture, provided with right- and left-hand stations to enable unloading and loading to be carried out during the traversing motion of the burner head. With the set up shown in Fig. 16, the ratchet teeth at *c* are being hardened, on two workpieces at once, which are clamped side by side at each station.

Quenching is effected, progressively, by a jet of soluble oil which is pumped through the nozzle *P*, located behind the two burners, and the oil is returned from the fixture tray to the sump by way of an overflow pipe. Hardening takes place during movement of the carriage from left to right, and rapid traverse is engaged automatically between the two workpieces, and for the return motion to the starting position. The twin burner head is carried on a linkage which provides for height adjustment, and transverse positioning of the head assembly along slideways in the carriage is effected by means of the handwheel. A sheet metal carrier, placed in a tray at the front of the machine, is provided for holding the workpieces to be hardened, and the finished parts are stored in wooden boxes. The output obtained at each of the four operations is 400 pieces per hour and a hardness of 60 Rockwell C is obtained. Eleven

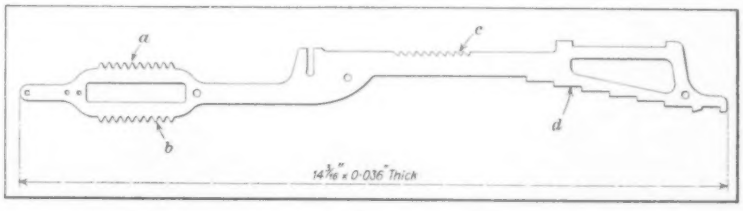


Fig. 17. Details of the component which is being hardened with the set-up shown in Fig. 16

different components are handled on this flame hardening machine.

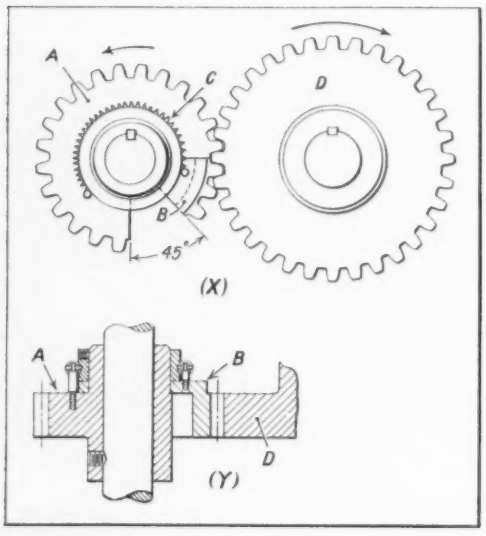
A Birlec high-frequency induction heating installation, seen in Fig. 18, which is supplied by a Philips generator of 15-kW. rating, is employed for the selective hardening of a range of 28 pressed steel parts and copper brazed assemblies for which the flame hardening process is not suitable. In the illustration, a duplex heating coil and work fixture arrangement is being used for treating two components at once, at *R* and *S*. The component, seen at *T*, comprises a pressing, 0·045 in. thick, to which a bush is copper brazed, and the ends of the three arms require to be hardened. The cycle time, controlled by a timer, is 10 sec., and, during the operation, the coils and work fixture are enclosed by a pivoted Perspex guard *U*. Equipment in the hardening shop also includes an Efco-Lindberg conveyor-type gas carburising furnace which incorporates the latest feature of air-blast quenching.

Other production methods developed by the company will be discussed in a further article.

Intermittent Gear Drive

By RALPH T. STEWART

The light duty gear drive arrangement, shown at *X* in the accompanying line drawing, provides for a regular interruption of the rotation of a driven gear while the driving gear is rotating continuously, and ensures that there is a smooth pick-up between the meshing teeth when the drive is resumed. As illustrated, the gears are designed to provide an interruption of the drive corresponding to 45 deg. of angular movement of the driving gear, but the method can be employed to give interruptions for larger or smaller angles, subject to certain limitations which will be indicated later.



An arrangement for obtaining an intermittent drive to one gear from the continuous rotation of another while ensuring a smooth pick-up between the mating teeth when the drive is resumed

At *A* is seen the driving gear, from which a 90-deg. section of the teeth and their associated web has been removed. This cut-out extends radially inwards to the periphery of the boss on the gear which can be seen projecting on either side of the toothed portion in the sectional view at *Y*. Surrounding this boss, on one side, there is a ring which is integral with a 45-deg. segment of gear teeth of similar form and face width to those on the driving gear. This segment *B* can turn freely on the gear boss, its angular movement being restricted by the cut-out in the driving gear, but is normally held against one side of this cut-out by means of the tension spring *C*.

With the gears in the position shown, the driver *A* has just turned the gear *D* through an angle of 270 deg. in the clockwise direction, and the first tooth of the segment *B* has come into engagement with the driven gear. Further rotation of the gear *A* will not be transmitted to the gear *D*, since its boss will rotate freely within the segment *B*, which is held stationary by the driven gear. As a result, the driving gear will make a further 45 deg. of angular movement before the other wall of the cut-out makes contact with the adjacent flank of the segment. During this period, the tension spring *C* is extended around the boss of the driving gear. As the cut-out surface of the latter abuts the segment *B*, drive to the gear *D* is resumed, and immediately the last tooth on the segment has come out of mesh, the action of the tension spring restores the segment to its original position.

A drive of this type can be effective in one direction only, but this direction can be reversed by transposing the attachment points of the tension spring. The limitations on the amount of angular interruption of drive possible with this arrangement are imposed by the extent to which the strength of the gear *A* can be reduced by the cut-out, and by the fact that the extremities of the cut-out lie on radii between adjacent teeth.

Producing Electrical Components on Variomatic Machines

Variomatic indexing-table, drilling, milling and tapping machines are being increasingly employed for the mass production of electrical and instrument components. As many as eight different operations can be performed at one chucking of the work, and two machines have recently be supplied to an electrical equipment manufacturer, one of which is being employed for the production of plug-pins from coiled material, and the other for finishing turned terminal sleeves.

A general view of the machine for making plug-pins is given in Fig. 1. The coil of heavy-gauge brass wire is carried on the floor-mounted support in the foreground, and the wire is drawn automatically through a roller-type straightening unit at the front of the machine by a mechanically-operated feed mechanism. Cam-actuated jaws incorporated in the feed mechanism grip the work material and advance it between the gripping members of one of a series of jigs on the rotating table of the machine. These gripping members are opened automatically at the preceding unloading position, and the work material passes through them until the end bears against a stop. Next, the gripping members are closed, and a length of wire sufficient to make one workpiece is cut off by the saw of a motor-driven unit coupled to the feed mechanism. The guard that encloses the saw of this unit is indicated at A in the close-up view Fig. 2, and a work-jig with the gripping members open may be seen immediately to the left.

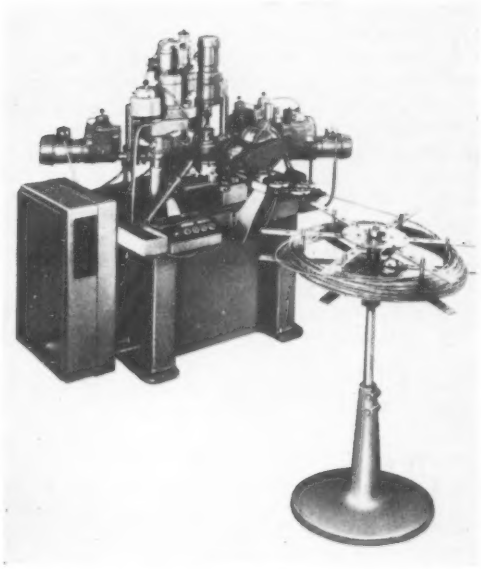


Fig. 1. A general view of the Variomatic machine for the production of plug pins from coiled material

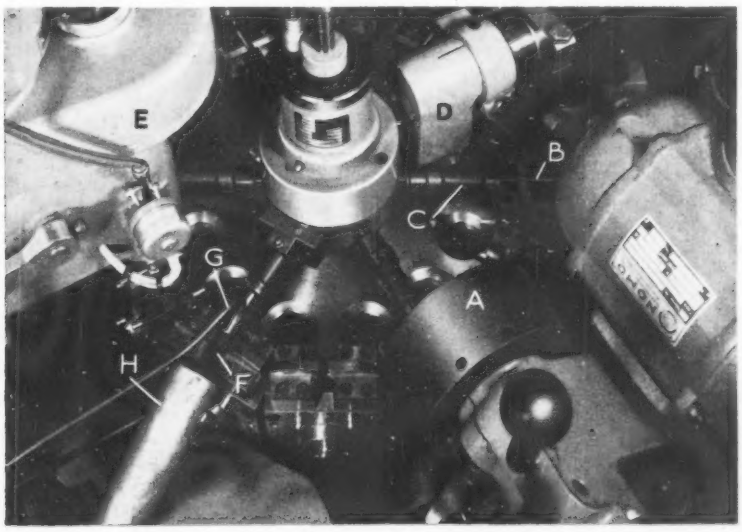


Fig. 2. Close-up view of the working area of the Variomatic machine, showing the work-holding jigs and some of the cutter heads

On this machine, the work-table moves in an anti-clockwise direction, as viewed from above, and the sequence of operations that is performed is shown diagrammatically in Fig. 3. The cutting-off operation is indicated at (1), and after the work-piece has passed through an idle station, it is machined to a smaller diameter at one end by means of a hollow milling cutter as shown in diagram (2). A workpiece in the position for hollow milling is seen at *B* in Fig. 2, and it will be observed that it is supported against the cutting thrust by a stop *C*. At the next station—(3) in Fig. 3—a special rear end drilling unit *D* machines a countersunk hole in the large end of the part.

Subsequently, the small end of the component is domed, with a box tool as seen at (4) in Fig. 3, the tool holder supporting the workpiece during the cutting operation. A transverse hole is drilled in the large end at station (5), in readiness for subsequent tapping. The small end of the pin is finish machined with a second hollow milling cutter at station (6) and the transverse hole is tapped at station (7). At station (8), a sawing attachment is employed to machine the narrow slot in the small end of the workpiece, to complete the machining of the part.

A hopper-fed screw driving unit is mounted above the ninth working station, as indicated at *E* in Fig. 2. This unit is controlled by a cam fitted to the indexing mechanism of the table and a screw is fed automatically from the vibratory magazine, inserted in the tapped hole in the workpiece, and screwed home. The screws are released, one at a time, by an electrically-operated escapement mechanism, and the driving unit is protected from over-load by a slipping clutch. Thus completed, the component is ejected at the tenth station, *F* Fig. 2. As each piece is ejected, it is blown by a blast of air from the jet *G* into the tube *H*, whereby it is delivered to a work-pan. With the set-up, 20 plug pins are produced per min.

SECONDARY OPERATIONS ON TURNED TERMINAL SLEEVES

The Variomatic machine for secondary operations on previously machined terminal sleeves is equipped with a vibratory hopper unit, into the bowl of which the turned workpieces are loaded at random. By the vibratory action, the parts are fed along a spiral track on the inside of the wall of the bowl, and blades and gates along this track ensure that only those components which are correctly orientated are delivered to the entry end of the delivery chute on the machine. Pieces pass down the chute to an escapement unit, which is controlled from the indexing mechanism of the Variomatic work-table. This escapement unit incorporates two stop members, which are withdrawn alternately, against spring pressure, so that one part at a time is released. Each part passes to an adjustable feeder, whereby it is loaded into a cam-operated jig on the work-table at the loading station. Controls are provided to check for correct positioning in the jig, and if a piece is incorrectly located, the machine is stopped immediately.

Operations performed are as follows:—(1) drill for subsequent tapping; (2) cut two slots at 90 deg. to each other; (3) tap; and (4) eject automatically, and clean the jig by means of an air

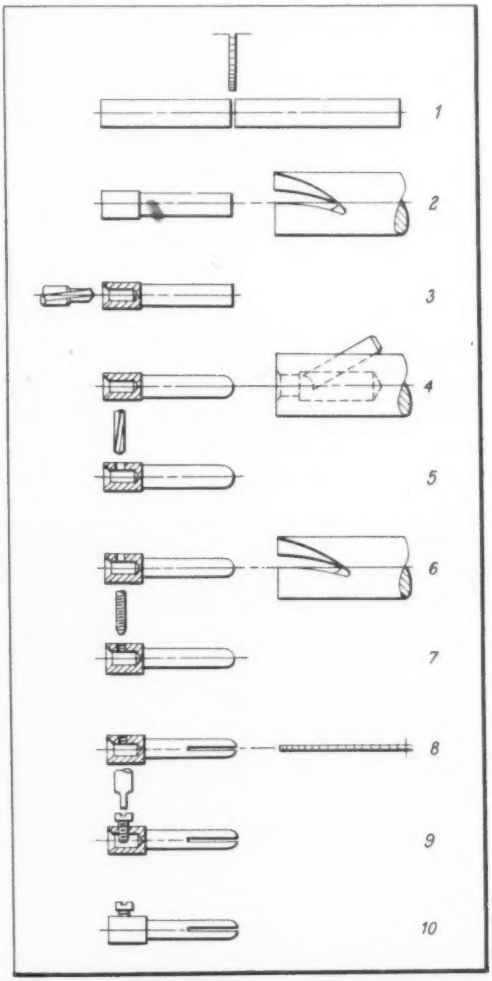


Fig. 3. Diagrammatic lay-out of the operations performed on the Variomatic machine for the production of plug pins

blast. An output of 22 pieces per min. is maintained.

The slots are cut by sawing attachments fitted to the spindles of standard drill heads, and if the machine has to be re-set for another component these attachments can quickly be replaced by conventional drill chucks. Interchangeable feed chutes and escapment units are available for use with the hopper feed mechanism, and the work-holding plate on the indexing table can be adapted to accept workpieces of different diameters. It is stated that the machine can be rapidly and easily re-set for a different type of workpiece.

The selling agents for Variomatic machines in this country are Sidney G. Jones, Ltd., 8, Balham Hill, London, S.W.12.

Installation for the Line Production of Locomotives

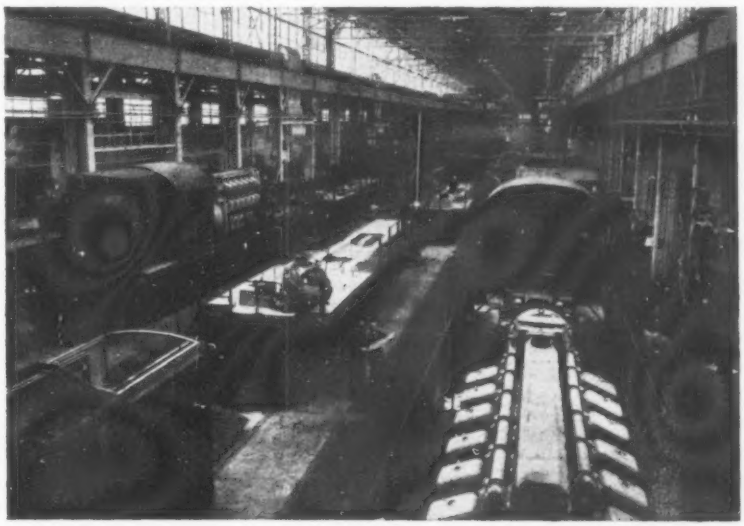
A new plant for the production of locomotives is now in operation at the works of Alco Products, Inc., Schenactady, N.Y., U.S.A., and is claimed to be the largest of its type in the world. Arranged for straight-line movement of the work during the various stages of production, the plant is installed in a building with an overall length of 1,190 ft., and provides for the complete manufacture of the locomotives, which are of the diesel-electric type. The main line is flanked by various sub-assembly areas, from which items such as cabs, hoods, machined parts, electrical panels, and the diesel engines, are introduced for assembly at the required stages.

Approximately half way along the line, there is a transverse aisle, and from this point the main line is divided into three separate runs. These three lines can be seen in the accompanying figure which is a view from the finishing end of the plant. The line at the left is reserved for shunting locomotives, that at the centre for special designs and locomotives for export, and that at the right for main-line, streamlined, types, such as the 1,800-h.p. DL-500 "World" export model.

As the locomotives leave the three tracks, they enter, successively, booths for final painting, and installations in which they are tested, whilst stationary, under varying load conditions, prior to final checking. There is a total of 13 cranes serving the building, of which five are rated at capacities greater than 35 tons, and one at 75 tons.

In addition to providing for the concentration of locomotive production, the new plant incorporates seven laboratories, which are engaged in research work on mechanical, metallurgical, welding, chemical, and thermal problems. The welding laboratory is at present investigating new methods of welding stainless-steel for heat exchangers, and the production of nuclear fuel-element plates, and has already developed an economic process for overlaying stainless-steel on carbon steel for nuclear and chemical applications.

The thermal laboratory is engaged in the study of problems connected with the transfer of heat and the flow of fluids, and is believed to be the first laboratory of this type to be equipped for studying full-size units, rather than reduced scale models.



A view from the finishing end of the straight-line installation at Alco Products, Ltd., Schenactady, U.S.A., for the production of diesel-electric locomotives

Operations on Components for Missile Guiding Equipment

By F. A. CUTHBERTSON*

The "AChiever" inertial-guidance system for directing missiles incorporates very accurate gyroscopes mounted on a stable platform which is isolated from the roll, pitch, and yaw of the missile by means of gimbals. At the launching site, an optical theodolite (similar to a surveyor's transit) is used to align the platform. During flight, larger gyros hold the platform steady, and small (accelerometer) gyros sense the missile's speed and direction. This information is fed into a computer which transmits signals to the rocket motor, when necessary, to bring the missile back on course, or, at the correct moment, to cut off the power.

Volume production of these AChiever units is now in progress at a new AC Spark Plug factory at Oak Creek, Wis., U.S.A., which was built with General Motors Corporation funds. The system is light in weight, compact, and relatively low in cost. It cannot be interfered with or jammed, and will not disclose the path of the missile because of any signal it transmits. Numerous successful tests have been completed, and the system is currently in use in two air-breathing missiles (the Navy Regulus and the Air Force Matador) to provide guidance throughout the complete flight. In addition, it is used in the Air Force Thor, a ballistic missile of 1,500-mile range, to guide it to a point in space at which it can be released from all control to proceed to its target.

* A.C. Spark Plug Division, General Motors Corporation, U.S.A.

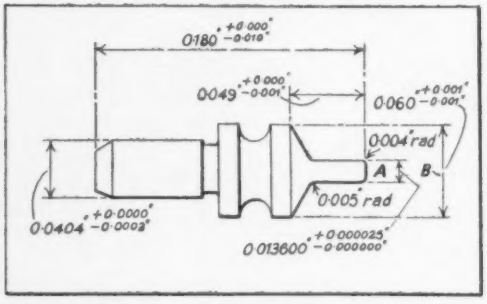


Fig. 1. A pivot for the AChiever inertial-guidance system which is produced to very close limits

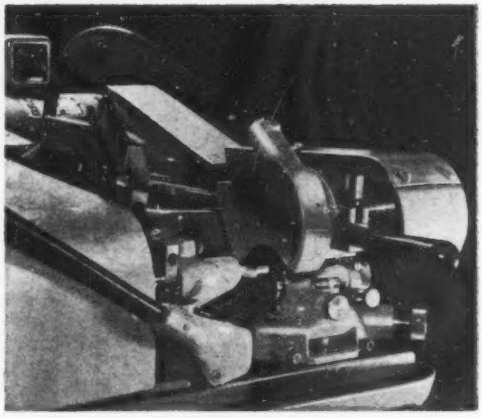


Fig. 2. Ceramic wheels are employed for semi-finishing, and tungsten-carbide wheels for finishing, on this pivot-burnishing machine

Manufacture of such an intricate and accurate system requires unusual techniques, close-tolerance machining, and special equipment. In this connection, it may be noted that work on the manufacturing problems was begun while research and development were still in progress, and as a result it was possible to begin volume production ahead of schedule.

Much of the production equipment—including some of the latest machine tools acquired—has been rebuilt to enable higher accuracy to be obtained. For the most precise work, the machines are run until they reach operating temperature before they are used. Some machines are never stopped until an entire batch of parts is finished. As much machining as possible is carried out at one setting of the workpiece in order to reduce the risk of introducing errors.

Typical of the very accurate parts required for the inertial-guidance system is the pivot seen in Fig. 1. A tolerance of 25 micro-inches must be maintained on the small-diameter end of this component, and a finish of 1 micro-inch or less must be obtained on this surface, the fillet, the rounded

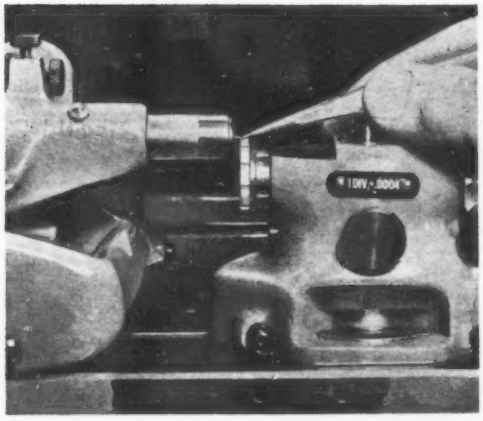


Fig. 3. Tweezers are used to place a pivot in the collet. The pivot is supported in a semi-circular notch in a carbide disc

corner, and the end of the pivot. Moreover, the diameter *A* must be held concentric with the diameter *B* within 0·0001 in. total indicator reading.

These pivots are made from high-speed steel drill rod containing 5 per cent molybdenum, 4 chromium, 2 vanadium, and 6 tungsten. After rough machining to a tolerance of 0·0002 in. on Tornos Swiss-type automatics, the parts are heat-treated to a hardness of 64 Rockwell C. Then, after being electro-chemically cleaned, the workpieces are finished on a Hauser pivot-burnishing machine, as shown in Fig. 2.

The pivot is gripped in a rotating collet, and supported in a highly-polished semi-circular notch in a carbide disc, as may be seen in Fig. 3. A ceramic wheel, rotating in a direction opposite to that of the work, is applied to semi-finish the pivot. At this operation fine chips are produced, and as much as 0·002 in. of stock is removed from some surfaces. A tungsten-carbide wheel is employed to finish the part, primarily by burnishing, with only slight cutting, and the diameter of the pivot shank is reduced by about 0·0005 in. at this stage.

Dressing of the ceramic and carbide wheels (to provide cutting grooves in the required direction on both the periphery and face) is a critical operation, and is carried out on a special machine equipped with a cup-shaped diamond wheel. Very fine cutting or shaving grooves, inclined at an angle of 10 to 30 deg. to the axis of the wheel, are thus produced. The ceramic wheel gives a surface finish of about 8 micro-inches, and the carbide wheel, the required 1 micro-inch finish. Duration of the burnishing cycle, which varies from 3 to 10 sec., is controlled by means of an electrical timer. To obtain the desired radius of 0·004 in., a chamfer of 30 deg. by 0·0025 in. is produced by burnishing, and this surface is finally honed by hand and polished.

Gimbal rings for supporting the gyroscopes of the inertial-guidance system are aluminium-alloy castings (356-T6 alloy) of approximately 36 in. diameter by 11¾ in. wide. The castings, as purchased, have been solution heat-treated. When received, they are subjected to five cycles of alternate heating and sub-zero cooling to stabilize the material and relieve stresses. Locating pads are milled and holes are bored on DeVlieg Jigmils and Pratt & Whitney profiling machines.

Precision boring of the gimbals is performed on

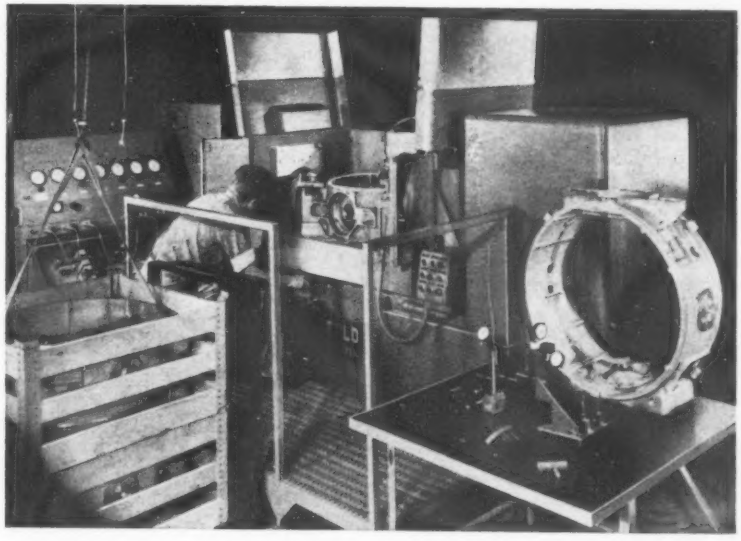


Fig. 4. One of the double-end precision boring machines employed for finish-boring and facing gimbals for the inertial-guidance system

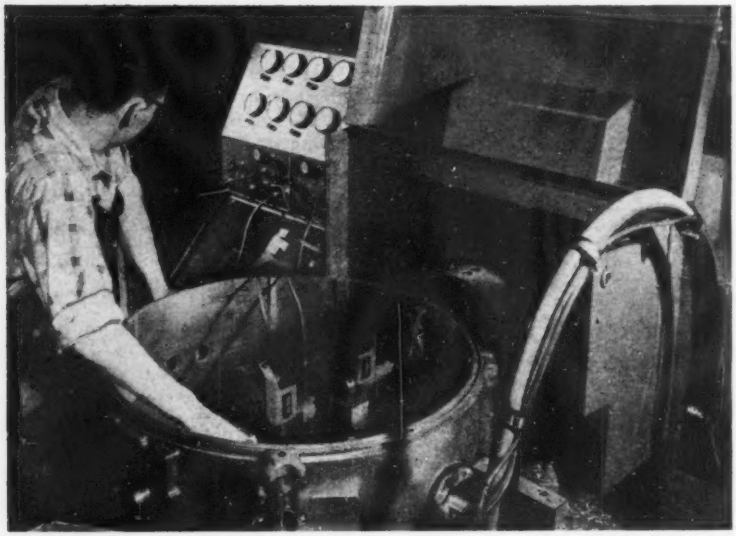


Fig. 6. Work is inspected while still in the machine by placing air gauges on support blocks which are built into the fixture

a battery of six Heald Bore-Matics, one of which is seen in Fig. 4. Two of the double-ended machines are used for rough-boring, two for semi-finishing and two for finishing. Each machine is equipped with interchangeable work-holding fixtures, as shown in Fig. 5, to accommodate gimbals of three different sizes. These machines are special in that the opposed, counterbalanced heads are aligned within 0·000050 in., and the temperature of the heads is maintained stable within 2 deg. F. by means of electrical resistance heaters which are built in below the bridges.

Each machine is also equipped with a complete set of Federal air and electronic gauges which are used in conjunction with a trammel for setting up and aligning the work-holding fixture, and inspecting the part while it is still in the machine. An electronic gauge head is mounted on the large trammel frame (which spans the table) to check the table travel in two planes for straightness and parallelism in relation to the axes of the heads. The gauging limits are ±0·00001 in. over a track of 12 in. and the gauge contact is arranged to bear against a reference block on the table.

Holes, varying from 1¼ to 8¼ in. diameter, are bored to the specified size, concentricity, and alignment within 0·0002 in. Faces on the gimbals, machined with cross-feeding attachments on the cutting heads, are held at right angles to the axes of the bores to very close limits. The work-holding fixtures have built-in support blocks for mounting

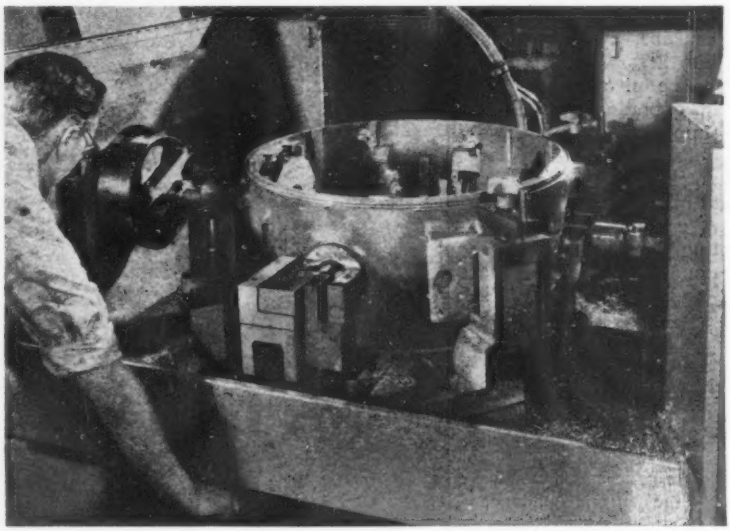


Fig. 5. On the precision boring machine shown in Fig. 4, gimbals are secured by means of spring-loaded clamps, which are tightened to a pre-set torque

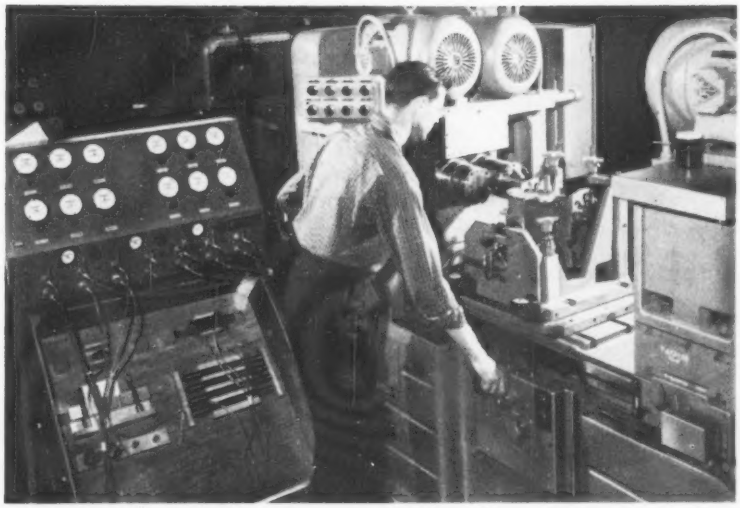


Fig. 7. Platforms for the inertial-guidance system are bored on this double-end machine which is equipped with a complete set of air gauges

the gauges, as shown in Fig. 6.

A Federal air-gauge and cradle fixture is used to check the squareness of the pivot axis to the bore axis of the gimbal. A precision mandrel, resting in a V-block, establishes the bore axis, and AirProbe contacts, which engage pivots, are cross-paired and connected to opposite sides of the air meter. If the two axes are not at 90 deg., the pivots will be canted, and each pair of contacts will be shifted in opposite directions from the nominal (zero) position. The unbalance caused by the shift is shown on the indicating meter.

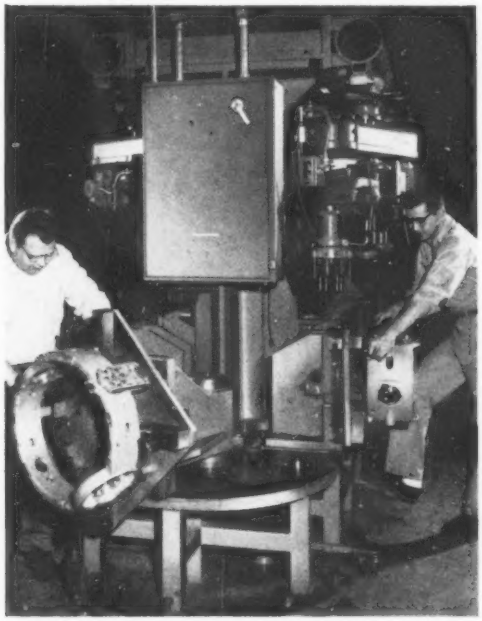


Fig. 8. Special machine for drilling, tapping, spot facing, or chamfering some 360 holes in each gimbal ring. The work is mounted on an index-plate.

Approximately $\frac{1}{32}$ in. of stock is removed per side in rough-boring, 0·025 in. at the semi-finishing, and 0·010 in. at the finishing stage. Carbide tools, lapped to a 2 micro-inch finish, are used for these operations. The tools are rotated at 812 surface ft. per min. and fed at the rate of 0·002 in. per rev. Boring and facing of the largest gimbal is carried out in only 26 sec. In securing the work in the fixture with spring-loaded clamps, the total force exerted is limited to 7 lb. by means of torque-controlled wrenches.

Similar operations are performed on the platforms for the inertial-guidance system on Ex-Cell-O double-ended, precision boring machines, one of which is seen in Fig. 7. The platforms, cast from the same aluminium alloy as the gimbals, are box-shaped parts approximately 12 in. wide by 9½ in. long by 11 in. high. Three pairs of gyro support holes, and a pair of pivot-mounting holes, are rough-, semi-finish-, and finish-bored after the bearing caps have been assembled to the castings. Three boring operations are required for each hole, because of the need for normalizing and stabilizing heat-treatment after roughing and semi-finishing.

As at the gimbal machining operation, a complete set of Federal air gauges is provided for setting-up the fixture and checking the platform. Stock removals are about the same, and similar tolerances are maintained. Lapped carbide boring tools are used for these operations.

A portable C-frame fixture and air gauge are

used to check the co-planar parallelism between the gyro mounting-rod bores in the platform. Precision mandrels are fitted into the bores to establish the axes, and V-blocks are mounted on the mandrels as references for the fixture. Spacing between the mandrels is determined by AirProbe contacts.

Approximately 360 holes—varying from $\frac{13}{64}$ to $\frac{7}{16}$ in. diameter—are drilled, tapped, spot-faced, or chamfered in each gimbal ring on the special machine shown in Fig. 8. This machine, designed by AC engineers and built by the Badger Tool & Engineering Co., is equipped with eight Walker-Turner multiple-spindle heads, four of which are arranged along each side.

Each gimbal is manually clamped, by means of four pads, to an index-plate which can be rotated to any desired position for machining various holes. The plate can be moved along vertical dovetailed ways (provided along both sides of the machine), and clamped to ways below the head to be used. Plungers, actuated by a combined pneumatic and hydraulic system, are used for locating purposes. For transferring the loaded index-plates from one side of the machine to the other, a pivoting type fixture is provided at each end.

Typical of the many precision machining operations performed on Hardinge lathes is that illustrated in Fig. 9. Here, a gimbal fork, made from 24S-T4 aluminium alloy, is being turned, faced, drilled, and bored. Finish-boring of a 0·037-in. drilled hole to a diameter of 0·0400 to 0·0402 in. by $\frac{5}{32}$ in. deep is carried out with a carbide dental burr mounted in a Tru-Hole high-speed drilling attachment made by the E. F. Vilter Co. With this attachment, the tool speed can be steplessly varied from 1 to 10,000 r.p.m.

Fig. 9. Aluminium-alloy gimbal forks are turned, faced, drilled, and bored on this lathe

Fig. 10. A standard hobbing machine is employed for producing fine-pitch gears with a tooth-to-tooth composite error of only 0·0003 in.

Fine-pitch gears for the inertial-guidance system are also made to extremely close limits. A typical specification for such a gear permits a tooth-to-tooth composite error of only 0·0003 in.; a total composite error of + nothing −0·0005 in.; and concentricity of the pitch circle with the integral shaft, within 0·0005 in. total indicator reading.

A standard Barber-Colman No. 6-10 hobbing machine, as shown in Fig. 10, is employed for gear cutting, and no subsequent grinding or shaving is required. The only thing special about the machine is the painstaking care that was taken in its construction, and the components were selectively assembled by skilled fitters to ensure the necessary indexing accuracy and rigidity. Accuracy is guaranteed to 0·0002 in. adjacent spacing and 0·0004 in. non-adjacent spacing on a 4-in. pitch diameter, spur test gear. Similar gears have been produced on special, ultra-precision machines built at high cost, but this machine involved a much lower capital investment. The machine has a single-lead worm, carefully scraped slides, and specially-selected bearings. A strict preventive

maintenance schedule, including daily take-up of the bearings, is observed.

With the set-up illustrated, a spur gear of 100 D.P., with 540 teeth, is being hobbed. This gear is made from Type 410 stainless steel having a hardness of 26 to 32 Rockwell C. Since the gears are only 0·093 in. thick, the blanks were originally made by stamping. It was found, however, that too much distortion resulted, and the blanks are now cut off from centrifugally-cast bars and ground with good results.

Carefully selected hobs, of Class AA or better, are used. Completed gears are checked on a Fellows No. 4 Red Liner by rolling them in mesh with a master. Any variation in centre distance is recorded on a paper chart, in addition to being shown on a dial indicator. Pressure between the master and the gear being tested is adjustable.

Gyroscope parts are carefully deburred. This work often requires more time and attention than that needed to machine the components. As seen in Fig. 11, 30-power microscopes are used to detect burrs and foreign particles, and a complete set of dental tools is employed for their removal. Vapour-, shot-, and sand-blasting are also employed for this work.

Inertial-guidance systems are assembled in dust-free rooms which are kept surgically clean. To aid in maintaining cleanliness, employees wear nylon hats, smocks, and shoe covers. A slight pressure of filtered air is maintained in the glass-enclosed, temperature-controlled assembly rooms. The temperature of master gauges, and of the workpieces, is allowed to become stabilized before checking is carried out. Assembled systems are checked in raceways which simulate the behaviour of a missile in flight.

Fig. 11. While the parts are observed under a 30-power microscope, burrs and foreign particles are removed with dental tools. Vapour-, shot-, and sand-blasting processes are also used for this work

Norton Ceramic Cutting Tools

An aluminium-oxide cutting tool, which has been developed recently by Norton Co., Worcester, Mass., U.S.A., has been used for certain turning operations for which conventional tools had proved unsatisfactory. In one of these operations, a number of chilled cast iron mill rolls had to be re-machined, each roll having a diameter of 13 in. and a hardness of 60 Rockwell C. The spindle speed range of the lathe which was used was such that the cutting speed was of the order of 45 ft. per min., and, at this speed, conventional tools failed in a very short time. With the ceramic tool, however, the cut could be taken at 66 ft. per min., with a feed rate of 0·008 per rev. and a depth of cut of 0·060 in. This tool, which also removed scores caused when the previous tools failed, was used for a total time of 2 hours 5 min. The taper over the 15-in. length of the roll was 0·001 in., and a good surface finish was obtained.

In another instance, a ceramic tool was employed for turning 13-in. diameter by 52-in. long Meehanite rolls, which were drilled transversely with eight ⅜-in. diameter holes, thereby presenting an interrupted surface to the tool. With previous tools, these parts were turned at a surface speed of 100 ft. per min., but with the ceramic tool the first cut was taken at 890 ft. per min. Subsequently, this figure was increased to 2,200 ft. per min., without exceeding the tolerance which was specified for taper.

It was discovered that the best surface finish was obtained at a cutting speed of the order of 1,600 ft. per min., since at higher speeds the chips were excessively hot and tended to adhere to the workpiece, thereby seriously affecting the surface finish.

By the use of ceramic tooling, the time required for this turning operation was reduced from 5½ hours to 30 min. The interrupted cutting conditions appeared to have no effect on the ceramic tool, but the company suggests that these tools might not have proved satisfactory had the mechanical shock which was imposed during this operation been more severe.

Friction and Lubrication of Machine Tool Slideways

Influence of Type of Surface, Lubricant Viscosity and Load on Friction Characteristics

By T. M. BIRCHALL, B.Sc., and A. I. W. MOORE*

A series of investigations is being carried out by the Production Engineering Research Association, Melton Mowbray, Leicestershire, in order to provide data for the design of slideways of machine tools. The first part of the work, which is summarized in this article†, was carried out with the general object of determining the effect of the type of surface (that is, hand scraped, periphery ground and cup ground), lubricant viscosity, and load, on the lubrication conditions (that is, boundary, mixed or fluid film) that occur between flat surfaces under substantially parallel sliding conditions. Of special interest were the effects of these factors on kinetic and static friction, stick-slip and the onset of full fluid film lubrication.

It may be noted that the terms boundary, mixed and fluid film lubrication are taken to have the following meanings:—

Fluid Film or Hydrodynamic Conditions, describe a condition where the sliding surfaces are completely separated by a lubricant film of appreciable thickness. In these circumstances, the resistance to motion is due entirely to the viscosity of the lubricant film, and no wear of the solid surfaces takes place.

Boundary Conditions exist when the sliding surfaces are separated by lubricant films of only molecular dimensions. Under these conditions, the friction is influenced by the nature of the underlying surface as well as by the chemical constitution of the lubricant, and the bulk viscosity has little or no effect on the frictional behaviour.

Mixed Conditions prevail when there are localized areas of fluid film lubrication with the remainder of the bearing area under boundary conditions.

Slideways for machine tools may be classified into two main groups, namely, those associated with cutting tool feed rates and which operate in the low speed range, from about 0·1 to 50 in. per min., and those associated with cutting speeds and which operate at speeds from 150 to 500 ft. per min., or more. The first group includes slideways for milling and horizontal boring machine tables, heads for planers and vertical boring mills, lathe saddles, and grinding machine wheel-heads. The second group includes planing machine table slideways, rams for shaping machines, and tables for vertical boring mills. Certain types of sliding systems fall outside these groups, since tables which operate at slow feeds are often provided with quick traverse mechanisms, and grinding machine tables, for instance, operate at speeds of the order of 100 ft. per min. In addition, very low sliding speeds are now frequently required for some forms of contouring and automatic-positioning mechanisms.

The loads on slideways are imposed not only by the weight of the sliding unit and the workpiece, when the latter is carried on the sliding member, but also as a result of the forces set up by the cutting action. In some instances, the weight of the table and work may be considerable compared with the forces set up by the cutting action, and in other cases the cutting forces may be responsible for the greater part of the load.

The desirable properties of machine tool slideways are, freedom from wear, scoring, and seizure; good friction characteristics, including the absence of stick-slip; accuracy of straight line motion, and adequate load-carrying capacity. Several schemes have been introduced with the object of improving some of these features, and include rolling bearing slides, hydrostatic slides, plastics slideway materials, and various types of lubricant.

The majority of machine tool slideways in this country consist of a cast iron on cast iron combination, as this arrangement permits the use of a relatively inexpensive constructional material to form both the structure of the machine and the surfaces of the slideways. Despite the fact that the operating conditions for different types of machine vary considerably, the basic form and design of the majority of machine tool slideways are similar, in that two nominally-parallel plane

* Senior Research Engineers, Production Engineering Research Association.

† Copies of the full report are obtainable from the Secretary, P.E.R.A., Melton Mowbray, Leics. (price £1 1s. 0d.)

surfaces are arranged to slide together, and provision is made for introducing a lubricant. A number of such surfaces can be combined in various ways to provide different slide arrangements, such as vee and flat, double vee, and dovetail. The conventional methods employed for finishing the cast iron sliding surfaces are scraping or grinding, the choice frequently depending on production rather than functional requirements. Loading on slideways is usually expressed in terms of the total load divided by the bearing area, and common values range from 10 to 80 lb. per sq. in. However, owing to asymmetrical loading conditions, and divergencies from true plane surfaces as a result of machining errors and deflections, it is highly probable that the load per unit area reaches much higher values at certain points on the slideways.

Although much fundamental work has been carried out in connection with problems of friction and lubrication, only a small amount is directly applicable to machine tool slideways. The work described here was designed to form a foundation for further studies of the behaviour of machine tool slideways. Conditions in the test equipment employed simulated as closely as possible those in part of a typical machine tool slideway, but provision was made for much greater control of such factors as geometrical accuracy, distribution of load, and the supply of lubricant. The results which were obtained illustrate the fundamental lubrication mechanism involved in adjacent parts of the sliding surfaces.

The load on machine tool slideways is not uniformly distributed over the sliding surfaces and depends on the particular element of the contact area which is under consideration. The resultant frictional force on the machine tool slideway thus involves the summation of the contributions of individual elements. In consequence, the form of the relationship between the coefficient of friction and the sliding velocity is altered. In place of a steeply descending curve, a much shallower curve is to be expected since the averaging process tends to obscure the basic relationship between coefficient of friction and sliding velocity. Part of the utility of the present investigation is that the underlying effects are sharply defined, whereas with larger scale equipment they tend to be masked due to this averaging process.

A variety of factors may affect the friction characteristics of sliding surfaces, including scalar effects of various types, such as that just discussed; variations in the supply of lubricant; rubbing effects due to particles entrapped between the mating surfaces; and many other matters peculiar to actual machine tool slideways. Further work is now in progress to investigate some of these additional influences.

VALUES OF SURFACE FINISH OF SLIDING SURFACES EMPLOYED FOR THE P.E.R.A. INVESTIGATIONS

	Direction	Surface finish (μ in. C.L.A.)		
		Hand scraped	Cup ground	Periphery ground
Upper slider	Longitudinal	22	14	4
	Transverse	21	6	7
Lower slideway	Longitudinal	24	14	4
	Transverse	25	12	8

Since the majority of machine tools have a cast iron on cast iron slideway combination, cast iron was selected as the material for the test slides. Three pairs of sliding surfaces were prepared by three different methods, namely, by hand scraping, periphery grinding and cup grinding. Numerical values of the surface finish of each test surface are given in the accompanying table.

In order that viscosity effects would not be confused with boundary lubrication effects, straight mineral oils containing no boundary additives were used as lubricants. The three lubricants employed had nominal viscosities of 100, 500, and 1,500 Redwood 1 secs. at 70 deg. F.

Two test loads of 20 lb. per sq. in. and 50 lb. per sq. in. were used, as these were considered fairly representative of the range of loads generally encountered in machine tool slideways.

FRICTION TESTING MACHINE

As previously mentioned, the performance of conventional machine tool slideways is probably influenced by numerous variable factors which are not easily isolated. For this reason the special equipment shown in Fig. 1 was built for the investigation. A schematic layout indicating the essential features of the machine is shown in Fig. 2.

The machine has a cast iron bed with horizontal slideways which are machined flat and parallel. A cast iron carriage *A*, fitted with five pairs of roller bearings as at *B*, runs on the horizontal slideways of the bed *C*, and is guided by two pairs of ball bearings which engage vertical machined faces on each side of the bed. The carriage can be reciprocated by either a high-speed or low-speed hydraulic cylinder (indicated at *D* and *E*, respectively) at velocities varying from approximately $\frac{1}{8}$ to 350 in. per min. over a length of 30 in. Provision is made for measuring the velocity of the

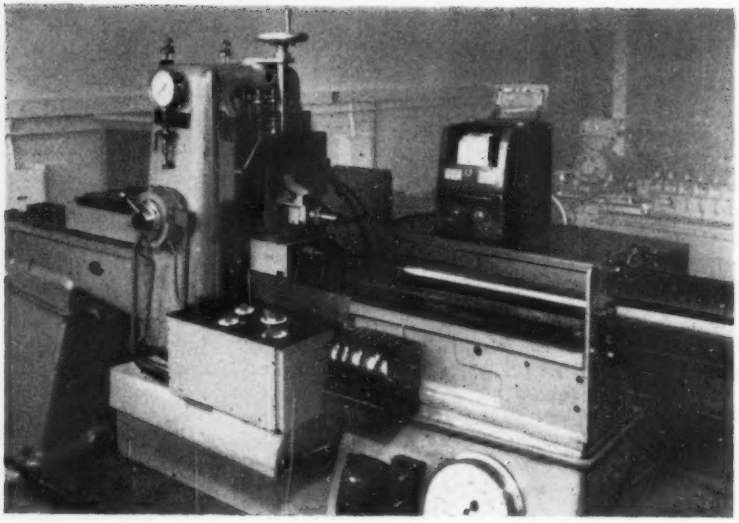


Fig. 1. General view of the special equipment that has been developed by P.E.R.A. for investigations into the friction and lubrication of machine tool slideways

carriage, and a system of trip dogs and valves enables the carriage to be reversed or stopped at any position in its travel.

The lower test slideway *F*, Fig. 2, is also seen in Fig. 3. It is 30 in. long by 5 in. wide, and is fixed to the moving carriage. The upper slider assembly (Fig. 4) slides on the lower slideway and consists of two cast iron pads (seen at *G* in Fig. 2) 3 in. long by 3⅜ in. wide, spaced 4 in. apart, and secured to a steel bridge piece. Motion of the upper slider assembly is restrained by a force measuring system. Lubricant is supplied by two drip-feed units as at *H*, Fig. 2, at two positions in front of the leading edge of each pad of the upper slider.

In order to reduce effects due to ambient temperature changes to a minimum, the equipment was installed in a room where the temperature could be controlled to within 4 deg. F. under most conditions.

Loads are applied to the centre of each of the two pads of the upper slider, through ball-ended struts *J*, Fig. 2, by two hydraulic piston and cylinder assemblies *K*. Pressure-oil is supplied to these cylinders from a hydraulic accumulator *L*, which ensures a uniform pressure, free from pulsations. The required oil pressure is obtained by placing suitable weights, *W*, on the accumulator piston, and this arrangement permits the application of a constant load to the sliding surfaces, even in the event of any vertical movement of the upper slider. Oil pressure, and hence the load applied to the slideway surfaces, is indicated by a pressure gauge coupled to the hydraulic system, close to the loading cylinders.

This arrangement of an upper slider with two independently-loaded pads was designed to minimize the possibility of a "tilted-pad" effect, such as was considered might occur with a single pad.

The frictional force is resisted by a pair of cantilevers whose resulting deflection is recorded and electrically amplified for measurement purposes. As indicated in Fig. 2, the upper sliding surface is connected to the extremities of the two relatively stiff canti-

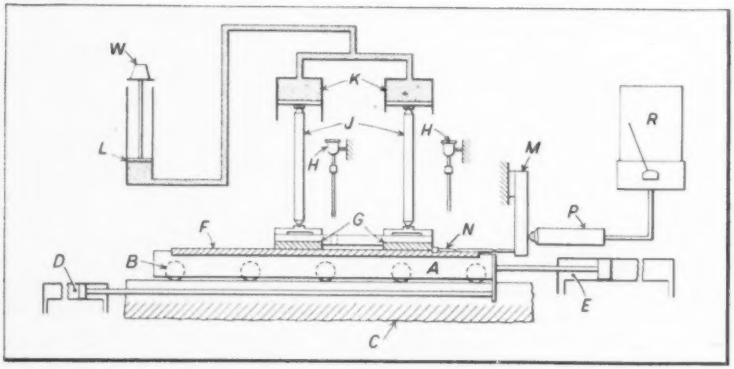


Fig. 2. Diagrammatic arrangement of the special test equipment. It incorporates a one-piece lower slide, traversed hydraulically, and a 2-piece upper slide to which various loads can be applied

levers M by the flexible ties N, one on each side of the slider. The ties are designed to impose no constraint on the slider in a vertical direction, and are positioned so that the restraining force is in the plane of sliding. The two cantilevers are connected by a cross-beam, the centre of which is engaged by the stylus of the displacement gauge head P. Thus, as the lower sliding surface is traversed, the friction force tending to carry the upper slider with it deflects the cantilevers and, hence, the stylus of the gauge head. The resultant signal from the gauge head is amplified and fed to the Talymin pen recorder R.

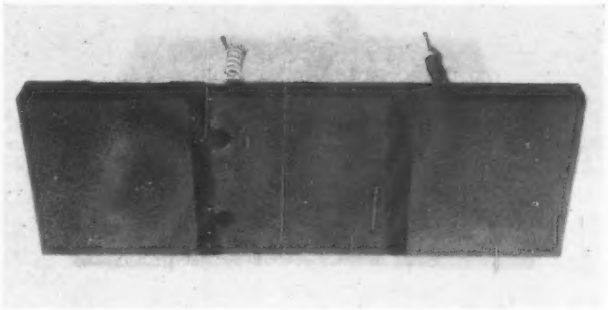


Fig. 4. A typical upper slider assembly for the P.E.R.A. tests

The frictional force measuring system was calibrated by applying incremental horizontal forces to the pair of cantilevers by means of weights and pulleys, and the scale of the pen recorder was then calibrated in 1-lb. units. Two measuring ranges were available on the pen recorder which corresponded to friction forces of 0 to 450 lb., and 0 to 90 lb. For the wider range, the friction force could be read to an accuracy of ± 1 lb., and on the more sensitive range to $\pm \frac{1}{4}$ lb.

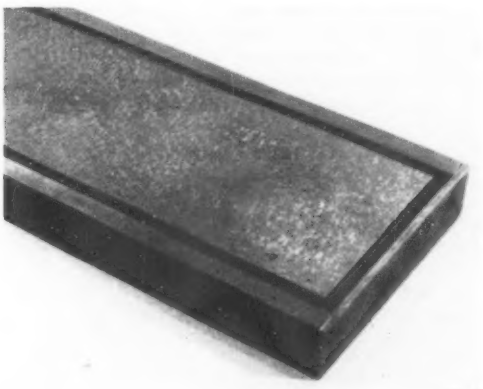


Fig. 3. One of the various lower slides that were used in the investigations

In the course of the investigation, variations in coefficient of friction with sliding speed were determined over a range of speeds from $\frac{1}{16}$ to 350 in. per min. A typical curve plotted to a logarithmic-linear scale is shown in Fig. 5.

The phenomenon of stick-slip was encountered at low sliding speeds, and the coefficients of friction for the conditions of "stick" and "slip" are indicated by dotted lines in Fig. 5. As the sliding speed increases, the coefficient of friction decreases as a greater proportion of the load is supported by partial hydrodynamic films. Eventually, a speed is reached where the coefficient of friction has a minimum value, and, under these conditions, the sliding surfaces are completely separated by a lubricant film, the thickness of which is of the same order of magnitude as the surface irregularities of the sliding members. At higher sliding speeds, the coefficient of friction increases according to the laws of hydrodynamics.

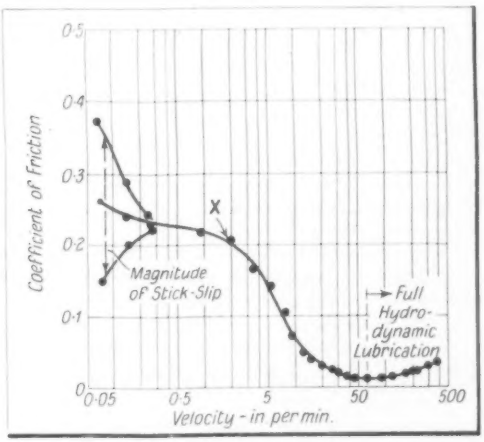


Fig. 5. Graph showing the relationship between the coefficient of friction and sliding speed for scraped upper and lower slides, lubricated with oil (viscosity 1,500 sec. Redwood 1 at 70 deg. F.), and with an applied load of 20 lb. per sq. in.

It was noted during the tests that as the sliding speed increased, the amplitude of stick-slip decreased until it could no longer be recorded with the instruments used. This speed is indicated on the curve by the junction of the broken lines with the single curve. At somewhat higher speeds, however, stick-slip still occurred, in most instances, and could be detected by the presence of vibration in the sliding unit. The speed at which stick-slip was no longer detected is indicated at *X* on the curve in Fig. 5.

Fifty-four curves similar to that shown in Fig. 5 were obtained for every possible combination of the three lower slideway surfaces, three upper slider surfaces, three lubricant viscosities and two loads.

In order to present the test results in a manner which would enable the main effects to be readily studied, they were statistically analysed and a series of average curves was constructed. In the construction of these average curves, stick-slip

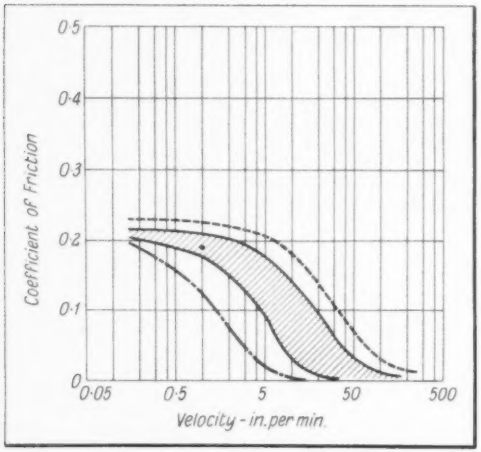


Fig. 6. Graphs showing the effect of various sliding surface combinations on kinetic friction. The results for scraped upper and lower slides are indicated by the dotted line; for a cup-ground upper slide and a periphery-ground lower slide by the chain dotted line; and for all other surface combinations by the shaded area

was neglected, the mean of the stick-slip envelope being plotted as the continuation of the kinetic friction curve. A separate analysis was carried out to determine the effects of the variable factors on stick-slip.

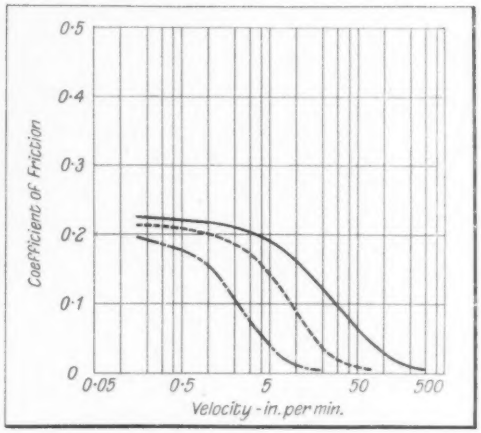


Fig. 7. Graph showing the effect of lubricant viscosity on kinetic friction. The curve in full line relates to a lubricant with a viscosity of 100 sec. Redwood 1 at 70 deg. F.; the dotted line to a lubricant of 500 sec. viscosity; and the chain dotted line to a lubricant of 1,500 sec. viscosity

The average curves indicating the effects of the various sliding surface combinations on kinetic friction are shown in Fig. 6. At all sliding speeds, up to that at which full fluid lubrication occurred,

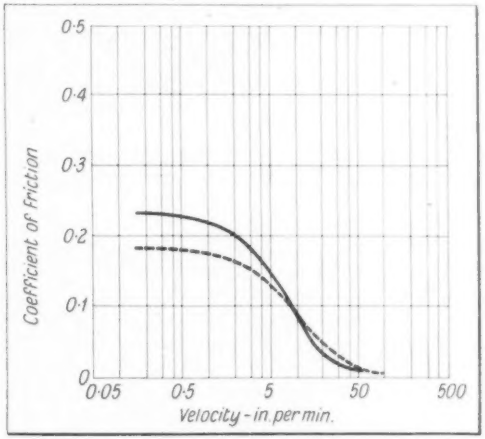


Fig. 8. Graph showing the effect of different loads on kinetic friction. The solid line is for a load of 20 lb. per sq. in., and the dotted line for a load of 50 lb. per sq. in.

the coefficient of kinetic friction was highest with the scraped surface combination.

The cup-ground upper slider with a periphery-ground lower slideway exhibited a lower coefficient of kinetic friction than the other combinations for conditions of boundary and mixed lubrication.

The remaining surface combinations gave rise to intermediate effects and are all contained within the shaded area in Fig. 6.

The average curves illustrating the effect of lubricant viscosity on the friction/speed relationship are given in Fig. 7. As would be expected, these curves show that for all sliding speeds up to that at which full fluid film lubrication occurred, the lubricant of highest viscosity exhibited the lowest coefficient of kinetic friction.

The effect of load on kinetic friction is shown by the average curves in Fig. 8. At sliding speeds below approximately 7 in. per min., the lower load (20 lb. per sq. in.) exhibited the higher coefficient of friction. At higher speeds, however, there was little difference in the friction for the two loads.

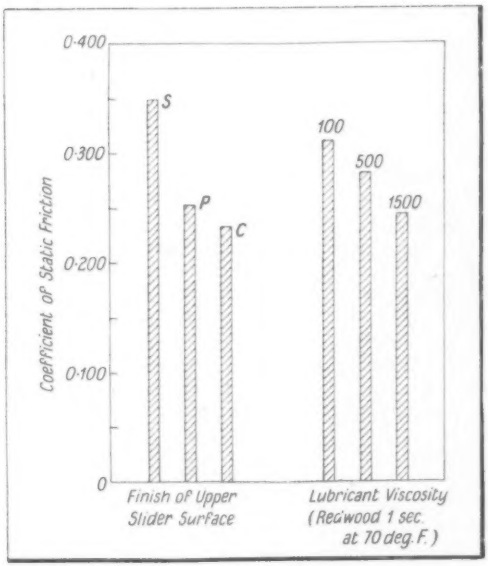


Fig. 10. Graph indicating the effect of finish of upper slider and lubricant viscosity on coefficient of static friction. *S*, *P* and *C* indicate scraped, periphery ground and cup ground surfaces respectively

In order to show the effects of the various test factors on the sliding speed at which full fluid lubrication occurred, the results are presented in the form of a bar chart (Fig. 9). The most favourable conditions for complete separation of the sliding surfaces were a high-viscosity lubricant, low load and ground surfaces. The worst conditions from this standpoint were a low-viscosity lubricant, high load and scraped sliding surfaces.

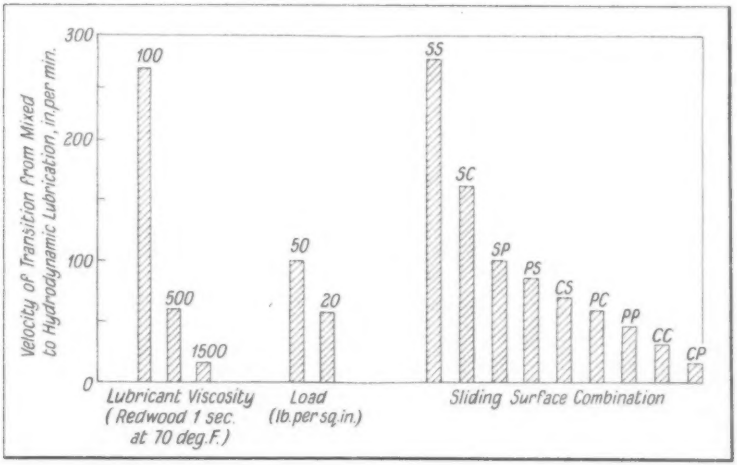


Fig. 9 (below). Bar chart showing the effect of various factors on the sliding speed at which full fluid film lubrication occurred. Sliding surface combinations are indicated as follows: *SS*, upper and lower slides scraped; *PP*, upper and lower slides periphery ground; *CC*, upper and lower slides cup ground; *SP*, upper slide scraped, lower slide periphery ground; *SC*, upper slide scraped, lower slide cup ground; *PS*, upper slide periphery ground, lower slide scraped; *PC*, upper slide periphery ground, lower slide cup ground; *CS*, upper slide cup ground, lower slide scraped; *CP*, upper slide cup ground, lower slide periphery ground

EFFECT OF VARIOUS FACTORS ON STATIC FRICTION

The results indicated that the only factors which had a marked effect on the coefficient of static friction were lubricant viscosity and

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the type of surface of upper slider. The type of surface of the lower slideway did not appear to affect static friction. The effects of the two factors are shown in Fig. 10, which indicates that the worst conditions with regard to static friction were a scraped slider and low-viscosity lubricant.

EFFECT OF VARIOUS FACTORS ON STICK-SLIP

The effects of various factors on the speed range over which stick-slip was detected are shown in the bar chart, Fig. 11. This chart indicates that stick-slip was most persistent with the combination of a low-viscosity lubricant, high load and scraped sliding surfaces.

The influence of different velocities and loads, also variation of the upper slider, on the magnitude of stick-slip (that is, the difference between the friction at "stick" and the friction at "slip") over a limited range of sliding speeds are shown in Fig. 12. The curves show that at a sliding speed of 0·1 in. per min., the magnitude of stick-slip was influenced both by the load and the type of surface of the upper slider. At this speed, the high load and scraped slider resulted in the most severe stick-slip. The effect of the slider surface became less pronounced as sliding speed increased until, at a speed of 0·3 in. per min., only the load had a marked effect on the magnitude of stick-slip.

Although a considerable amount of data has already been obtained, the investigation should not be considered in any way complete, and further work is necessary to provide a more complete understanding of the mechanism of lubrication between substantially parallel sliding surfaces. As mentioned earlier, many additional factors may affect the performance of a machine tool slideway in practice, for example, various scalar effects, lubricant supply, influence of foreign particles in the lubricant, and standing time. Thus, although the results of this investigation showed that, in general, the frictional characteristics of the ground surfaces were superior to those of the scraped surfaces, extraneous factors relating to particular conditions of service may sometimes favour the use of scraped surfaces.

Where such conditions exist, the better results frequently claimed for scraped surfaces may possibly be due to the following reasons:—(1) Where the distribution of lubricant is inadequate, scraped surfaces may

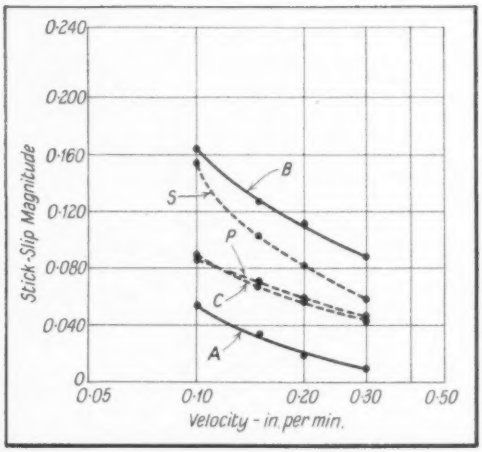
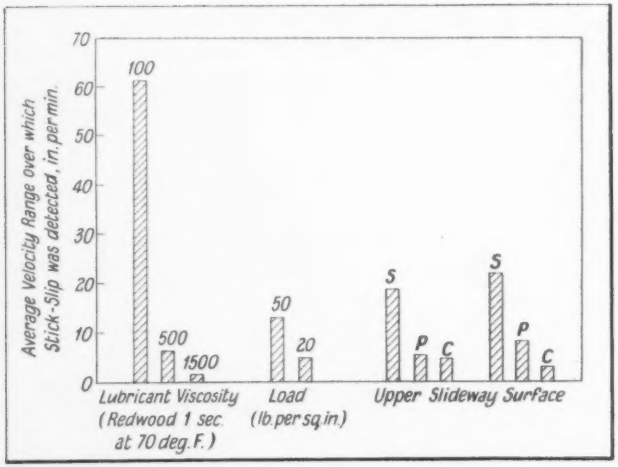


Fig. 12. Graph showing the effect of various factors on the magnitude of stick-slip (that is, the coefficient of friction at the end of "stick" minus the coefficient of friction at the end of "slip"). The effect of the finish of the upper slide is shown by the dotted-line curves, *S*, *P* and *C* indicating scraped, periphery ground and cup ground finishes respectively. The effect of load is shown by the solid-line curves, *A* and *B* indicating loads of 20 and 50 lb. per sq. in. respectively

Fig. 11 (below). Chart showing the effect of various factors on stick-slip. *S*, *P* and *C* indicate scraped, periphery ground and cup ground surfaces, respectively



provide flow-paths whereby lubricant may gain access to areas which might otherwise be starved. (2) Scraped surfaces can probably be prepared to a higher degree of flatness, and, therefore, conformity, thus distributing the load on the slideway more effectively, and reducing any tendency for localized regions of high loading. (3) Foreign particles in the lubricant may be passed between scraped surfaces without causing excessive damage. If contact does occur, it is probable that the damage will be confined to a localized high spot on the scraped surface. On the other hand, if such particles contact closely-mating ground surfaces, they are likely to cause surface damage which would become more severe and extend over a much greater area, as illustrated in Fig. 13. (4) After a slideway has been at rest under load for a considerable period of time, most of the lubricant would be squeezed out from between ground surfaces. With scraped surfaces, however, small reservoirs of oil may remain in the scraped pockets and thus provide initial lubrication of the surfaces until the normal mechanism of lubrication comes into effect.

SUMMARY

This investigation has demonstrated the fundamental frictional behaviour of flat cast iron slides under substantially parallel sliding conditions, when lubricated with an adequate supply of clean mineral oil. By making use of these results, and bearing in mind the possible influence of other factors (including those already mentioned), designers should be able to form some idea of the type of lubrication to be expected in a machine tool slideway under a fairly wide range of conditions.

In order to supplement the data provided by this investigation, work is continuing at P.E.R.A. to study scalar effects, lubricant supply, and other factors on larger-scale equipment which has recently been constructed. The performance of different additive-type lubricants, solid lubricants such as molybdenum disulphide, and of various slideway materials (including plastics), is also being examined. These investigations, it is intended, will provide further data relating to the design of slideways for machine tools.

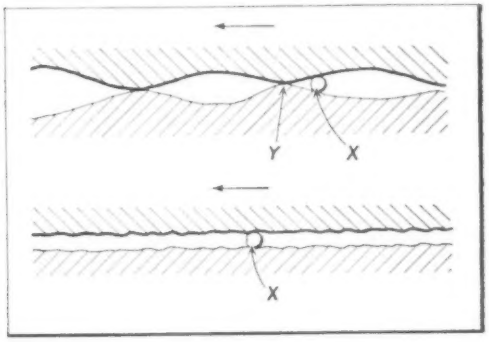
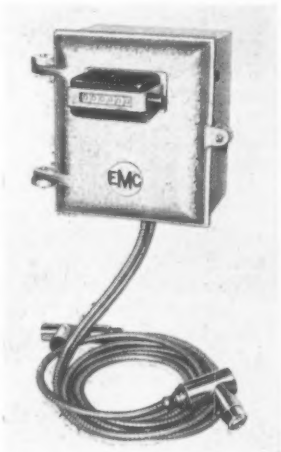


Fig. 13. Diagrammatic representation of the effect of a foreign particle *X*, entrapped between a pair of scraped surfaces (above) and a pair of ground surfaces (below). With the scraped surfaces, damage is confined to the area indicated at *Y*, whereas extensive damage may be caused to both ground surfaces

A Transistorized Electronic Counter

Recently introduced by Electronic Machine Co., Ltd., Mayday Road, Thornton Heath, Surrey, the latest type P.12.C. electronic counter, here shown, incorporates transistors which are said to ensure exceptional reliability. The compact amplifier, which is built into the unit, receives signals from a selenium barrier-type photo-cell, and, through a relay, operates an electro-magnetic counter which has a maximum counting speed of 300 per min. It is stated that a photo-cell of the type employed can be readily focused, and will transmit signals when located at distances up to 18 in. from the parts to be counted if a 6-volt 6-watt bulb is fitted. With a 6-volt 24-watt bulb, the corresponding distance is 48 in.



The Type P.12.C. Transistorized Electronic Counter Introduced by Electronic Machine Co., Ltd.

If required, the amplifier and relay can be arranged to operate a visible or audible warning system. Alternatively, a solenoid or contactor can be operated to provide for automatic control of various functions.

The S.B.A.C. Static Exhibition—1

The nineteenth flying display and static exhibition of products of members of the Society of British Aircraft Constructors was held recently at the Royal Aircraft Establishment, Farnborough. This year's display served to mark the 50th anniversary of the first official aeroplane flight in Britain, which was made on the same site on October 16, 1908, by S. F. Cody. A distance of 496 yards was covered at an average height of 50 to 60 ft. This modest beginning lent emphasis to the impressive array of some 48 British aircraft, more than 40 aero engines, and static exhibits by 350 participating member firms, from which it was apparent that the rapid development in many fields, evident at last year's S.B.A.C. exhibition, had again been maintained.

For the second successive year, a large section of the exhibition was devoted to a special display of guided missiles, which included eight different types. These examples afforded evidence of the concentrated effort and progress of more than 400 firms, engaged, either directly or indirectly, on work of this nature. Seaslug, which is to be the standard anti-aircraft equipment of the Royal Navy, was shown by Sir W. G. Armstrong Whitworth Aircraft, Ltd., in association with The General Electric Co., Ltd., and Sperry Gyroscope Co., Ltd., Bristol Aircraft, Ltd., Bristol Aero-Engines, Ltd., and Ferranti, Ltd., jointly exhibited Bloodhound, a surface-to-air weapon ordered for the R.A.F., which was shown with its launcher, limber, loading trolley, and launch control post.

A demonstration of the launcher loading of Thunderbird (The English Electric Co., Ltd.) was given, and this missile was also seen with its loading trolley, mobile launcher and elevating frame. It has been chosen for anti-aircraft defence, by the Army and the R.A.F. Fireflash, the first air-to-air missile in service with the R.A.F., was shown by the Fairey Aviation Co., Ltd., The Plessey Co., Ltd., and E. K. Cole, Ltd., and assembly and testing were demonstrated. Other examples included the Firestreak air-to-air weapon (De Havilland Propellers, Ltd.) and two private-venture anti-tank weapons, by Pye, Ltd., and Vickers-Armstrongs (Aircraft), Ltd. Short Brothers & Harland, Ltd., in association with Elliott Brothers (London), Ltd., showed an SX-A5 general-purpose test vehicle, which is in current use for research on homing problems. This vehicle is equipped with a two-stage parachute recovery system.

In the static exhibition, the large-scale participation by many different firms in the country's guided weapons programme was again reflected by the high proportion of participants showing items connected, in some way, with this field. Numerous exhibits of electronic and associated equipment emphasized the extensive development work which is being carried out in connection with weapon guidance problems, and the steadily-increasing number of applications of such equipment in aviation and industry.

M.O.S. EXHIBITS

On the stand of the Ministry of Supply were shown typical examples of the work of the National Gas Turbine Establishment, Pyestock, the Royal Radar Establishment, Malvern, the Royal Aircraft Establishment, and the Inspectorate of Electrical and Mechanical Equipment. The N.G.T.E. exhibit comprised a "mock-up" illustrating the simulated flight testing of a ram-jet engine, facilities for which have recently been installed at Pyestock. Two cells are provided, each of 12 ft. diameter, with an available length of 25 ft. for the installation of the test engine. Both cells are designed to operate on air flow at pressure ratios up to 9:1, and temperatures up to 600 deg. K. Altitude simulation is obtained by means of ejectors, operating on the same supply, which are capable of lowering the pressure within the cell to 1/15th of an atmosphere.

For investigating air-intake configuration, which is critical, one cell is arranged to provide a flow of air over the outside of the intake, as well as into it, whereas in the second, all the available air is delivered into the intake. The former type is arranged for testing with a supersonic air supply, over a range of pressure, temperature, and incidence at the intake. For velocities up to Mach 1·6, the speed is variable by means of slotted nozzles, but for higher speeds, fixed nozzles are employed. In the second type, the air supply is metered, and provision is made for measuring thrust. The exhaust can be delivered either directly to atmosphere or through the ejectors, and temperatures up to 2,000 deg. K. can be tolerated. To keep running time to a minimum, photographic recording techniques are employed, and use is made of a digital computer. All the development and performance testing of a ram-jet engine, necessary before it can be flown, can be carried out in these two cells. In addition, they provide data unobtainable in flight.

The exhibit of the Royal Radar Establishment was concerned with research into the problem of cooling electronic equipment for high speed military aircraft, in which air cooling cannot satisfactorily be employed because of adiabatic heating effects. A liquid-cooled, integrally-ducted chassis, in a sealed, insulated container, was shown, with another chassis of soldered tubular construction. Two integral chassis materials currently under investigation are electro-formed seamless nickel honeycomb with a wall-thickness of 0·010 in., and a commercial, ducted aluminium sheet.

AUTOMATIC INSPECTION MACHINE

Of especial interest to the production engineer was the I.E.M.E. exhibit, which comprised a Bryant Symons jig borer converted for use as a fully automatic, tape controlled, 3-dimensional inspection machine. Air bearings with oil mist lubrication have been provided for the slideways, and special floating recirculating ball nuts and leadscrews, with preloaded ball bearings, substituted for the normal feed arrangements. The nuts and leadscrews, it may be noted, were supplied by Coventry Gauge & Tool Co., Ltd., and the machine was equipped with the Ferranti control system. The latter was employed to move the work through a programmed true mean path, in relation to the stylus of an I.E.M.E. universal measuring head, which was coupled to a Magna-Gage indicator (Southern Instruments, Ltd., agents, Buck & Hickman, Ltd.) and a recorder (Record Electrical Co., Ltd.).

Fig. 1. Electronically-controlled rotary positioning table with control equipment supplied by E.M.I. Electronics, Ltd.

So long as the component under inspection was accurate, there was no deflection of the stylus, and the recorder traced a straight line in the centre of the chart. Any errors were recorded as deviations from the central position, and their magnitude was ascertained from the calibrated grid on the chart. The component was a typical elaborate machined aero-engine casting, with several bores, bosses and faces, on which a total of 13 checks was completed in a cycle time of 20 min. This programme was controlled by 1,800 ft. of ¼-in. magnetic tape.

Features which can be checked on the machine included the diameter and position of holes; ovality, taper and lobing; flatness, position and angularity of faces; widths, depths and profiles; and concentricity and symmetry. It was stated that, under temperature-controlled conditions, the machine was accurate within 0·0003 in. to 0·0005 in.

The I.E.M.E. universal measuring head and measuring system, which are covered by a provisional patent, were described in MACHINERY, 92/1329—6/6/58. This article discussed an application of the system to an adapted milling machine with Ferranti control, and the jig borer here considered represents a further stage of development. This machine has a capacity of 32 in. by 21 in. by 7½ in. Future development work will be concerned with extension of the application of this system to include the checking of gears and the surface-finish of engineering components, and large structural members such as aircraft spars.

AUTOMATIC MACHINE TOOL CONTROL

Ekco Electronics, Ltd., Ekco Works, Southend-on-Sea, Essex, showed their latest type E 117 machine tool control system, in which provision is made for automatic programming by means of punched cards. With the Ekco system, it may be recalled, feed-screw rotation can be controlled within 1/500th of a turn, so that, with a 10 t.p.i. feed-screw, work-table settings can be made within 0·0002 in. Since the final approach is unidirectional, the effects of backlash are eliminated. Normally, the equipment for co-ordinate setting comprises a combined control unit with a separate traverse unit for each feed-screw. For demonstration purposes, the system was applied to a rotary table, operated by a single control unit calibrated for circular measurement.

With the recently-developed punched card

Fig. 2. Titanium products exhibited by Imperial Chemical Industries, Ltd., Metals Division

equipment, information for a maximum of 23 holes can be stored on each card, and a machine can be programmed to function automatically, until all operations with a particular size of drill have been completed. The equipment employed for the Ekco system, it may be noted, is relatively simple, and can be fitted to existing as well as new machines. Maintenance of the electrical equipment requires little skill.

An electronically-controlled rotary positioning table, representing one of the latest applications of their range of machine tool control systems, was demonstrated by E.M.I. Electronics, Ltd., Hayes, Middlesex. This unit was of the type shown in Fig. 1, and was operated in conjunction with a closed circuit industrial television channel. On the screen was shown a view of a scale associated with the table, which served to illustrate the high accuracy of setting.

The display of Ferranti, Ltd., Hollinwood, Lancs., included a number of items relating to guided weapons, among which may be mentioned printed circuits, produced at the company's Wythenshawe and West Gorton factories. Circuits of this type are employed in the radar and electronic guidance and control system for Bloodhound, and are also produced for a wide range of applications in computers, and radio, television, and electronic devices. Another product of the Wythenshawe factory is an electro-hydraulic control valve with linear pressure/current characteristics, and a particularly rapid response. A recent development by the company's electronics department is a ceramic/metal seal for electronic valves, which combines high mechanical strength, good electrical insulation, vacuum-tightness, and the ability to withstand temperatures up to 700 deg. C. A pictorial display on the stand illustrated examples of the computer control of machine tools. It was stated that advances have continued in this field, one result of which is that it is now possible to machine the impressions in coining dies for gas turbine blades by this method.

Elliott Brothers (London), Ltd., Century Works, Lewisham, London, S.E.13, showed a wide range of electronic instruments and equipment for flight navigation and control, which included a miniature airborne computer. Attention was also drawn to the fact that many mathematical processes can be carried out by simple mechanical devices, and that, in suitable circumstances, mechanical computation can afford a number of advantages. Among the latter may be mentioned high accuracy in relation to size, reliability, robustness, versatility, and low energy requirements. The mechanical engineering division of the company has specialized experience in this field, and offers a consultation service.

Exhibited by Solartron Electronic Group, Ltd., Thames Ditton, Surrey, for the first time, was their Minispace analogue computer, which has been designed to meet the need for a compact, moderately-priced unit for general use. Housed in a cabinet 51 in. high, 20 in. wide, and 30 in. deep, the unit has ten drift-corrected amplifiers, each of which may be used for summing, sign reversing, integration, or the simulation of a transfer function over a wide range. Any problem requiring up to ten such operations may be solved or simulated, and typical examples include two simultaneous second or third order differential equations; and one equation of the fourth or fifth order. Two such instruments may be coupled together and operated from the control panel of one of them, as a 20-amplifier unit, or as two 10-amplifier units with separate control panels.

FERROUS PRODUCTS

The English Steel Corporation, Ltd., River Don Works, Sheffield, 9, and North Street Works, Openshaw, Manchester, staged a joint exhibit of the products of three of their subsidiary companies. English Steel Forge & Engineering Corporation, Ltd., displayed a range of drop forged components for airframes, engines, undercarriages and rockets, and a number of these items were shown both in the "as-forged" and fully-machined conditions. English Steel Tool Corporation, Ltd., showed a

comprehensive range of engineers' cutting tools of various types, and English Steel Rolling Mills Corporation, Ltd., special aircraft and tool steels.

Samuel Fox & Co., Ltd., Stocksbridge Works, Sheffield, and Steel, Peech & Tozer, The Ickles, Sheffield, 1, both subsidiaries of the United Steel Companies, Ltd., also exhibited jointly. Samuel Fox & Co., Ltd., drew attention to their range of 18 special aircraft steels, and gave specification details. Also on display were electron micrographs showing their structure, at a magnification of 30,000 ×. A cut-away drawing of the Rolls-Royce Avon engine served to illustrate a typical application of rolled steel rings produced by Steel, Peech & Tozer, who also exhibited actual examples. Another of their exhibits was a forged steel ring, of a type employed in aircraft disc brake assemblies.

Talbot Stead Tube Co., Ltd., Green Lane, Walsall, Staffs., showed examples of their seamless heat-resisting stainless steel tubes, both in straight and manipulated forms, and a representative selection of small machined components—mainly for gas turbine flame tubes—in which the company also specializes. Another product represented was the range of bright drawn turned and ground steel bar, which is available in sizes from $\frac{3}{16}$ in. to 8½ in. diameter, and examples of bi-metal tube were also on view. This firm, it may be noted, has recently begun to produce bright drawn wire.

TITANIUM PRODUCTS

There was again evidence of the increasing availability and application of titanium, and in this connection attention may be drawn to the main exhibits of Imperial Chemical Industries, Ltd. (Metals Division), Kynoch Works, Witton, Birmingham, 6, shown in Fig. 2. These items comprised a helicopter cowl fabricated in 26 s.w.g. material, a complex blown flap duct assembly, and a titanium ingot weighing 4,200 lb. Both of the fabricated exhibits were produced by J. R. Bramah & Co., Ltd., Sheffield—the helicopter cowl for Bristol Aircraft, Ltd., and the flap duct assembly for Vickers-Armstrongs (Aircraft), Ltd.

Stated to be the largest yet made in Europe, the ingot was melted in new furnaces at the I.C.I. Metals Division works at Witton. On the same stand were shown examples of Kynal roll-welded aluminium heat transfer sheet, and copper and aluminium Tube-in-Strip. Both these materials have passages formed integrally in the sheet. Another product displayed was Integron, an integrally-finned tubing. Marston Excelsior, Ltd., Wobaston Road, Fordhouses, Wolverhampton, Staffs., a subsidiary of I.C.I., Ltd., also displayed examples of titanium components, including aircraft heat-exchangers, and flash butt-welded rings.

NICKEL AND ASSOCIATED PRODUCTS

Participating for the first time, Metachemical Processes, Ltd., 41-43 Gatwick Road, Crawley, Sussex, showed a number of examples (Fig. 3) of micrograin nickel electroforms. Produced by a special patented technique, electroforms of this type are said to have resistance to impact and abrasion superior to that of stainless steel, and are employed for protecting the leading edges of propellers, rotor-blades, and air-intakes. As regards general properties, the material is similar to pure nickel sheet, and the hardness ranges from 450 to 700 V.P.N. Cross grain tests on specimens of 450 V.P.N. hardness show an ultimate tensile strength of 135,000 lb. per sq. in., with an elongation of 4·5 per cent. A satisfactory method of examining the micro-structure has not yet been found, but it has been estimated that for at least the first 0·003 in. deposited, the grain size is of the order of 1 micron.

The exceptional properties of the electroforms are attributed to the use of special electrically-conductive plastics coatings on the patterns, which are plated in a bath free from organic additives, and the resulting deposit is of high purity. A cast replica of the surface to be protected is first prepared, and is coated with a layer of the plastics material mentioned. A flash coating of copper is then applied, and the suitably-masked pattern is

Fig. 3. Micrograin nickel electroforms, made by Metachemical Processes, Ltd.

immersed in the plating bath for the required period. A wide variety of forms can be produced in this manner, including sheet and tube. Since the material is springy, and can be bent without cracking, removal from the pattern normally presents no difficulty, and the electroforms are readily fitted to the surfaces to be protected.

The same company gave working demonstrations of the Dalic portable anode plating technique, which was described in MACHINERY, 83/824—23/10/58. Recent developments in this field include the introduction of solutions and techniques for the deposition of alloys comprising various combinations of tin, lead, cadmium, zinc, antimony, copper, silver, gold and indium. Development work on nickel and chromium, and metals of the platinum group, is also at an advanced stage. It is stated that alloys can be produced by these methods, which are otherwise unobtainable.

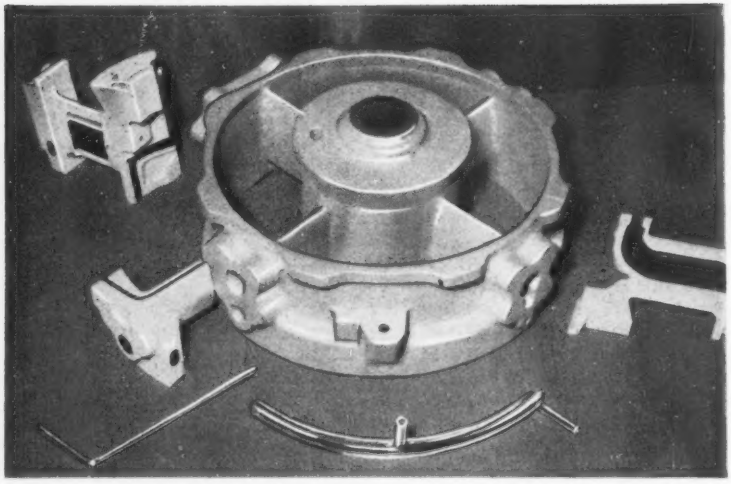


Fig. 4. A Glass-cored casting, and some typical examples of glass cores, displayed by Kent Alloys, Ltd.

Henry Wiggin & Co., Ltd., Wiggin Street, Birmingham 16, announced the recent addition of a new heat and creep resisting alloy to the Nimonic range. Known as Nimonic 105, the new material is a development of their nickel chromium cobalt molybdenum alloy, Nimonic 100, and it has greater resistance to creep at very high temperatures. The minimum life to rupture at 7 tons per sq. in., and 940 deg. C., is 50 hours, whereas the corresponding figure for Nimonic 100 is 30 hours. In addition, Nimonic 105 has improved resistance to a specific type of corrosion, associated only with very high temperaures, and the high-grade fuels, such as aviation kerosene, currently in use. The new material has been tested by the British aero engine industry, and is now in production.

Joseph Sankey & Sons, Ltd., Albert Street, Bilston, Staffs., showed an interesting variety of fabricated items in stainless steel and heat-resisting alloys, including typical gas turbine components such as flame tubes, discharge nozzle assemblies, and turbine casings. Also on view were examples of propeller spinners, in aluminium alloy. These exhibits served to draw attention to some of the specialized products of the company, which include, in addition, components for missile development work. In this connection, attention may be drawn to a large weld-fabricated liquid fuel rocket combustion chamber, made for the Ministry of Supply, and used for rocket motor research. Incorporating passages for regenerative cooling, and fuel pre-heating, a combustion chamber of this type was exhibited on the stand of the Ministry of Supply in 1956, and was described in MACHINERY, 89/753—28/9/56.

Various items produced by Sankey-Telcon, Ltd., by the Mercast process, were also exhibited. Sankey-Telcon, Ltd., who are members of the G.K.N. Group, and are owned jointly with the Telegraph Construction & Maintenance Co., Ltd., operate the Mercast process under licence from Mercast (Great Britain), Ltd. The exhibits included waveguides in magnesium, aluminium and copper-base alloys, and airframe, gas turbine and missile power unit components in a variety of materials. Among the latter may be mentioned stainless heat-resisting steels and Nimonic. Typical limits maintained on the smaller waveguides are of the order of $\pm 0{\cdot}002$ in., and on the larger examples, $\pm 0{\cdot}004$ in. The surface finish on a representative aluminium component, as cast and vapour-blasted, is 30 to 40 micro-inches, r.m.s. Methods employed in producing some of the waveguides exhibited were described in MACHINERY, 90/818—12/4/57, and those for a turbine nozzle guide vane outer flange segment, in Nimonic, were discussed in a later article (93/777—1/10/58).

A display on the stand of Birfield Industries, Ltd., Stratford House, London, W.1, comprised the joint exhibits of Kent Alloys, Ltd., Temple Manor Works, Rochester, Kent, The Phosphor Bronze Co., Ltd., P.O. Box 74, Bradford Street, Birmingham 5, and Laycock Engineering, Ltd., Victoria Works, Sheffield 8. Kent Alloys, Ltd., showed several examples of castings in aluminium and magnesium alloy, including a large radar pedestal, of 270 lb. fettled weight, in L.53 aluminium-magnesium material. Although difficult to produce, since it incorporated heavy sections, this casting was stated to be free from porosity. Another large casting, in similar material, is employed for a hose drum for flight refuelling.

Of special interest were the exhibits shown in Fig. 4, which served to illustrate a patented glass core casting technique, developed by the company. The component is of aluminium alloy, and with it were displayed typical sectioned portions, to show the various cored passages. Also on view were some of the hollow glass cores, examples of which may be seen in the foreground in Fig. 4. The cores are produced by ordinary glass-blowing techniques, from a special thermal shock resisting and high melting-point glass, and are employed in conjunction with conventional sand moulds. They are removed from the completed casting by dissolving them with hydrofluoric acid, and a surface finish of high quality is obtained in the cored openings.

Since the glass cores are rigid and hollow, they are light, accurate, self supporting and self venting. Consequently, they can be employed to produce long, slender, passages, which, if necessary, may be of complex configuration. Because they are hollow, and the walls are relatively thin, their removal by etching is facilitated. Hitherto, the process has been confined to aluminium alloys, but it is also being developed for other materials. Glass-cored components have already been cast successfully in iron. Exhibits by The Phosphor Bronze Co., Ltd., included castings in copper-base and stainless alloys, produced by the shell moulding, Shaw, and CO_2 mould processes. Also displayed were a number of cold extrusions in steel, produced by the German Neumever process. Laycock Engineering, Ltd., showed typical Layrub flexible couplings, auxiliary drive shafts, and a number of ferrous and non-ferrous castings and forgings.

MAGNESIUM EXHIBITS

On the stand of Magnesium Elektron, Ltd., Clifton Junction, Manchester, attention was directed to the potentialities of magnesium as a tooling material, for which it is available in plate from ¼ to 2½ in. thick. Among the advantages of magnesium for this purpose may be mentioned its light weight, high strength, and the ease with which it may be welded and machined. Some typical press tools and a drill jig were exhibited. The weight of the latter was 3 lb. 14 oz., whereas the weight of an equivalent steel tool would have been 15 lb. 8 oz. By using magnesium for such tools, it was pointed out, it is often possible to employ female labour on work which would normally required mechanical aids. Among a number of extrusions and stampings in Elektron magnesium alloys may be mentioned a heat exchanger tube section, with thin, closely-pitched helical fins.

J. Stone & Co. (Charlton), Ltd., Woolwich Road, Charlton, London, S.E.7, featured X-ray quality sand, die and precision castings in high-strength aluminium, magnesium-zirconium, and copper-base alloys, and drew attention to their recently-introduced heat-treated M.S.R. magnesium alloys. The latter, which contain silver, rare earth metals, and zirconium, are notable for their high proof stress, which ranges, typically, from 10 to 13½ tons per sq. in., and the ultimate tensile strength is 15 to 19 tons per sq. in. When castings are made in this material, there is close correspondence between the properties of samples taken from various portions, and those of separately-cast test-bars. In one instance, the average proof stress of seven

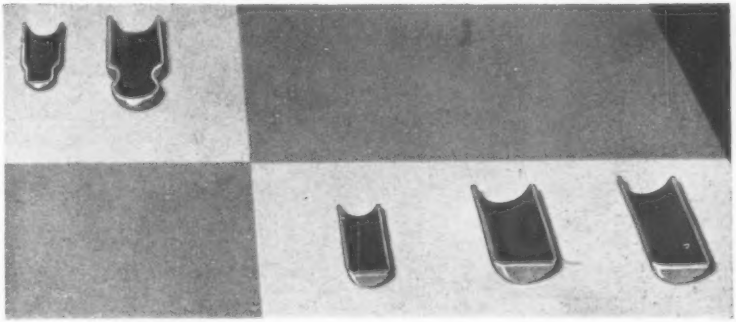


Fig. 5. Typical pistons, produced by a high-accuracy cold drawing and rolling technique developed by Wilmot Breeden, Ltd.

such samples taken from an annular casting of 24 in. diameter was 11·4 tons per sq. in., whereas three separately-cast test-bars showed an average of 11·95 tons per sq. in. The ultimate tensile strengths were 16·9 and 17·2 tons, respectively. This high degree of uniformity is maintained both in thick and thin sections, and is partly attributable to the two-stage heat treatment.

METAL MANIPULATION PROCESSES

Three main exhibits on the stand of Wilmot Breeden, Ltd., Goodman Street, Birmingham 1, served to draw attention to some of the metal manipulation processes in which they specialize. One was a group of fabricated hollow inlet guide vanes and stator blades, made by a technique that has been developed for producing components of this type. Each such vane or blade has one or more perforated tubular ducts, through which hot air is distributed for anti-icing purposes. This duct is surrounded by an envelope of the required profile, which it also serves to strengthen. The envelopes are formed from flat blanks in nickel chromium alloy, by a series of press operations, and are subsequently brazed at the trailing edges, in a controlled protective atmosphere. Similar methods are used for brazing the ducts to the envelopes, and attaching the end fittings. For the latter, induction heating is normally employed. Among advantages of this method of construction may be mentioned high accuracy, minimum weight for a given envelope size, efficient heat transfer because of uniform envelope thickness, and design flexibility as regards the configuration of the end fittings.

Another exhibit by the same company comprised a number of examples of cold flow turned parts, which included conical shapes in various materials. These items served to illustrate the application of this process to the production of components with thin, close-tolerance walls, and thick diaphragms or flanges, from flat blanks. Materials that can be manipulated in this manner include Nimonic. A recent development, also featured, is a method of cold drawing and rolling cupped shells from flat blanks, to a high standard of accuracy and surface-finish.

Some typical examples are shown in Fig. 5, and as may be observed (top left) shouldered and spherical-ended forms can be produced. For the manufacture of small pistons, for example, the process may enable important economies in material and production time to be effected. In addition, it ensures a favourable grain formation. A representative component, of 1·4 in. diameter, produced from steel sheet, had a surface hardness of 750 V.P.N.

Teddington Aircraft Controls, Ltd., Cefn Coed, Nr. Merthyr Tydfil, Glam., showed an impressive range of bellows in stainless steel, Nimonic, and titanium, some of which are illustrated in Fig. 6. The large example, seen in the centre of the group, is of 2 ft. 6 in. diameter, and was produced from seam-welded sheet, and that at the upper right, of 10 in. diameter, was made in a similar manner, from titanium. This company, it may be noted, supplies bellows in sizes ranging up to 7 ft. in diameter.

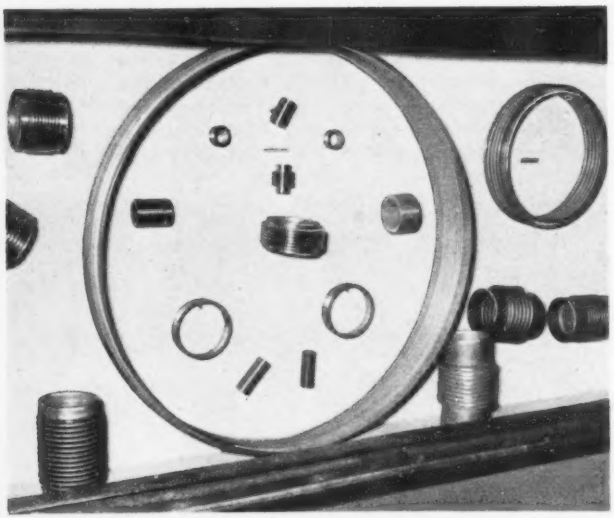


Fig. 6. Metal bellows, in Nimonic, stainless steel and titanium, exhibited by Teddington Aircraft Controls, Ltd.

The display by Northern Aluminium Co., Ltd., Bush House, Aldwych, London, W.C.2, was concerned mainly with the capacity afforded by the recent installation of a 4,000-ton plate stretching machine, and a 4,000-ton forging press, in their works. In this connection, mention may be made of a large forging in Noral B.755 alloy, for a prototype aircraft component, which had been produced on the 4,000-ton forging press.

Some other exhibits at the S.B.A.C. Static Exhibition will be considered in a further article, to be published shortly.

Cast-Master Automatic Loading and Unloading Unit for Die Casting Machines

An automatic loading and unloading unit for use in conjunction with single- or multi-impression dies on pressure die casting machines, where inserts must be positioned in the cavities, has recently been introduced by Cast-Master, Inc., 23,901 Aurora Road, Bedford, Ohio, U.S.A. One of the medium-size machines from this company's range, which now extends up to 1,200-tons capacity, as briefly described in MACHINERY, 91/495—30/8/57, is shown with the new equipment in place in Fig. 2. The injection equipment is at the left-hand end, and the machine, which is of the cold chamber type, is arranged to operate on an automatic cycle, controlled electrically by the equipment in the cabinet at the right.

The automatic loading and unloading unit, which is employed to position the inserts and remove the finished castings, takes the form of a fabricated steel structure, and is clamped to the two upper tie bars between the machine platens. Part of the structure overhangs the operator's side of the machine, and it incorporates two cylindrical guide bars which support a sliding carriage moved by a long-stroke hydraulic cylinder. A downward extension of the carriage forms the insert-positioning and unloading arm. In the illustrations, the machine is arranged for casting the end rings and inter-connecting pole pieces of rotors for small electric motors, one of which is shown in Fig. 1, together with a lamination stack insert.

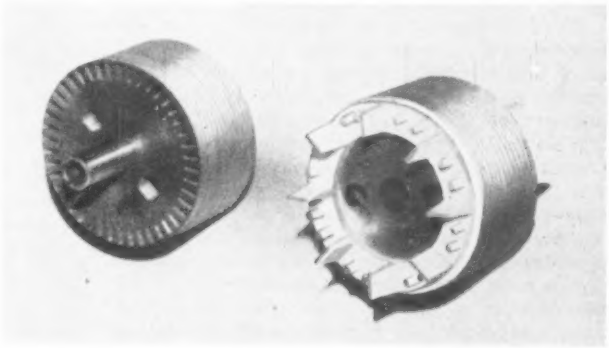


Fig. 1. A rotor for a small electric motor, the end rings and pole pieces of which are pressure die cast in aluminium alloy

For convenience in loading, the laminations are assembled on split tubular dowels of spring steel, which grip the bores and hold them in

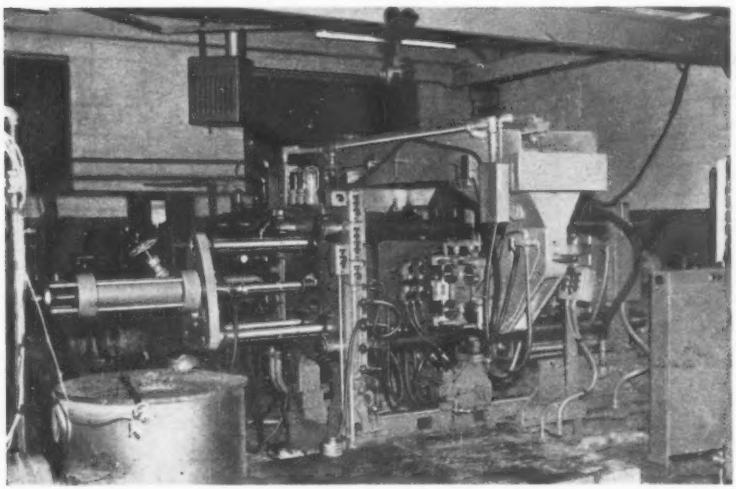


Fig. 2. General view of the Cast-Master cold-chamber die casting machine fitted with the new automatic insert-loading and casting-removal equipment

the required angular relationship to each other. Overheating of the dowels, and difficulties that might otherwise be associated with the removal of the finished castings, are eliminated by automatically ejecting them through holes in the die and the fixed platen, after the metal has been injected. A view showing the side of the loading arm which will be adjacent to the fixed die member when the arm is in the advanced position, is given in Fig. 3, and it will be seen that each lamination stack is accommodated in a circular holder, the latter being slotted on each side to clear the projecting end of the dowel when the arm is retracted.

The four lamination stacks are loaded into the arm during the casting cycle, and, after the injected metal has solidified, the dies are opened and the carriage is advanced to align the stacks of laminations approximately with the cavities. The moving platen is then brought forward so that two dowels which it carries engage bushed holes in the arm to ensure accurate location, and a hydraulically-operated ejector mechanism within the arm is actuated to push the spring dowels and lamination stacks out of the holders. The ends of the dowels enter locating holes in the face of the fixed die member so that the lamination stacks are supported horizontally in readiness for the closing of the die later in the cycle. Ejectors are then operated to push the rotors, cast at the previous cycle, out of the cavities in the moving die member, and into holders in the opposite side of the arm to that seen in Fig. 3.

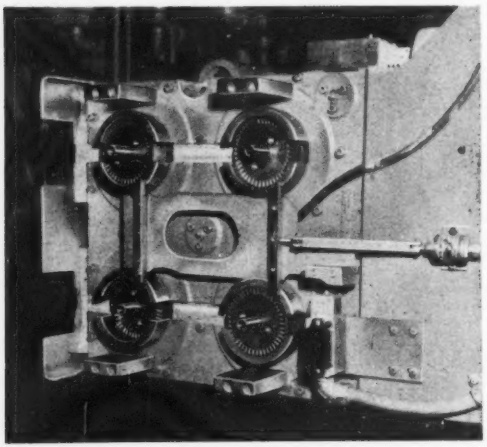


Fig. 3. The stacks of laminations are assembled on split tubular spring steel dowels which hold them in the correct angular positions while they are placed in the holders of the loading arm

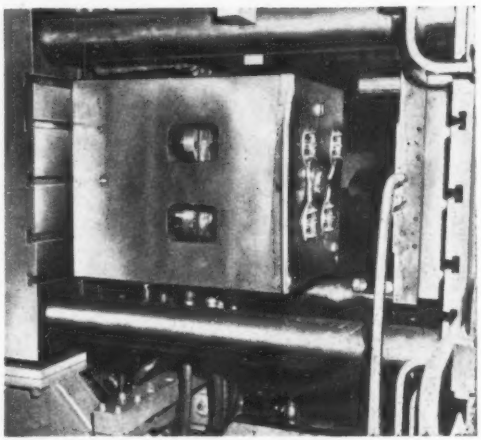


Fig. 4. In this view of the face of the moving die member, details of the runner system can be seen. The runner bars are clipped from the castings as they are ejected from the die into the holders in the unloading arm

A view of the face of the moving die member, from the rear of the machine, is shown in Fig. 4, with the rotors and the runner bars still in place. From this view, it will be seen that the central injection position of the machine is employed, and that the gates extend partially round the faces of the end rings. When the rotors are pushed out of the die cavities into the holders in the unloading arm, the runners are clipped off against the edges of the circular holders during the first part of the ejector stroke. Next, the die is opened and the arm is retracted, the runner system being freed and allowed to fall clear so that it can be recovered for subsequent re-melting. The moving die is then advanced again, so that the rotor stacks are enclosed by the cavities, and another shot is made. During this time, the cast rotors are ejected from the arm and new stacks are placed in the holders on the fixed die side.

PRODUCTION OF TYPEWRITERS.—A total of 36,213 standard typewriters, including those of the electric type, and 35,605 portable typewriters were produced during the second quarter of this year, representing a value of £2,219,000. Of these totals, 22,463 standard, and 24,466 portable, machines were produced for export, representing a value of £1,160,000. The corresponding figures for value for the same period last year were £2,350,000 and £1,147,000.

Ringspann Chucks

An article published in MACHINERY, 91/871—11/10/57, was concerned with Ringspann spring-steel clamping discs made by the German firm of Albrecht Maurer K.G., for whom K. S. Paul, Ltd., Great Western Trading Estate, Park Royal Road, London, N.W.10, are the sole representatives in the United Kingdom. The discs are intended for use in conjunction with fixtures and mandrels for gripping cylindrical workpieces, either by the periphery or the bore, and include clamping elements in cup shapes, of deep and shallow designs, for gripping relatively long, and short parts. Radial slots extend alternately from the inner and outer edges, and when axial pressure is applied at the centre, the flat base of the cup assumes a dished shape. As a result, the cup diameter is reduced and a radial clamping action is applied to the periphery of the work.

The makers also produce a range of chucks incorporating these cup-shaped elements, and clamping diameters ranging from 20 to 800 mm. (0·8 to 31·5 in.) can be provided. These chucks are usually made to suit specific workpieces and surfaces to be machined, and are available in two basic designs, known as the register and barrel types, with shallow and deep recesses respectively.

An example of the barrel-type chuck is seen in Fig. 1, and it will be noted that this particular unit enables the bore, the outer face, and an external surface of the workpiece shown to be machined at one setting. When an axial load is applied in the direction of the arrow by the centre bolt *A*, the clamping element *B* is caused to grip the workpiece *C*, on the periphery. In addition, a slight axial movement of the clamping element causes the work to be urged against the pins *D*, in the chuck body *E*, so that positive endwise location is ensured.

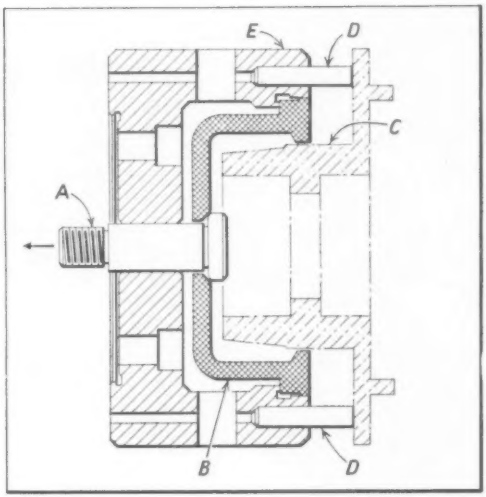


Fig. 1. Ringspann barrel-type chuck and cup-shaped clamping ring with deep recess for gripping a component by the periphery

Fig. 2 shows a chuck of the register type, with a shallow recess, and the workpiece is here indicated at *F*. In Fig. 4 is shown a typical selection of chucks of the register type with the workpieces immediately adjacent to the corresponding chucks.

Alternatively, short mandrel-type chucks are available for gripping workpieces by the bores. With this arrangement, which is illustrated in Fig. 3, a shallow clamping element *G*, identical with that used in a register-type chuck, is mounted with the recess facing inwards and located against a flange. A circular plate,

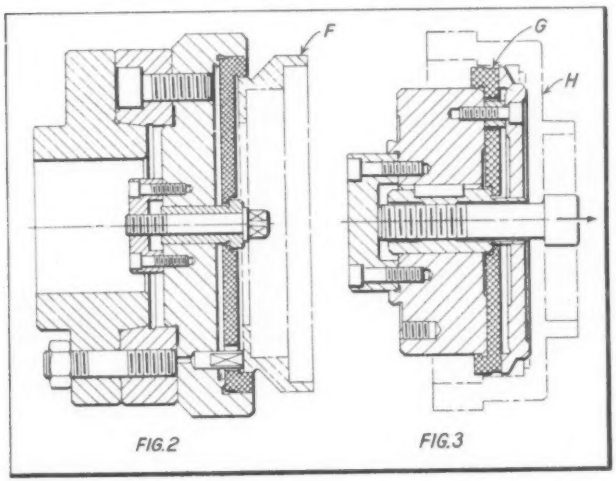


Fig. 2. Ringspann chuck of the register type

Fig. 3. A mandrel-type Ringspann chuck for gripping a workpiece by the bore

Fig. 4. Typical Ringspann chucks of the register type, with workpieces immediately adjacent to the corresponding chucks

secured by bolts, holds this clamping element in position against the flange face. When the axial load is applied in the direction of the arrow, the clamping element is caused to expand so that its outside surface engages the bore of the workpiece, indicated at *H*.

Various operating arrangements, involving the use of screws, cams, and levers, for instance, can be incorporated in the chucks, and provision can be made for hydraulic, pneumatic, and mechanical power, also for hand actuation. To prevent the ingress of swarf, the radial slots in the clamping elements are filled with a silicone rubber compound.

It is claimed that with these chucks, concentricity is held within close limits, and clamping forces of considerable magnitude can be applied. Moreover, the clamping movements are sufficient to enable parts produced to comparatively wide tolerances, during previous machining operations, to be securely gripped.

Bassaire Pressurized Assembly Cabinet

As was mentioned in MACHINERY, 93/390—13/8/58, a gold medal was recently awarded at the Seventh International Exhibition of Inventions for a pressurized assembly cabinet developed by John Bass, Ltd., Crawley, Sussex, and a general view of this equipment is shown in the accompanying figure. Designed originally to provide a dust-free atmosphere in which miniature ball bearing could be assembled, the cabinet has a glass desk-type top, through which the operator can view the work, and an open front to provide access to the interior.

The dust-free air which is introduced into the cabinet builds up an internal pressure, thereby preventing the ingress of contaminated air through the opening. In addition to the assembly of miniature bearings, this equipment is used in the precision instrument and optical industries.

Bassaire pressurized cabinet which has been developed for precision assembly work

Large Extrusion Press Rams Reconditioned by the Master-Hone Process

The use of the Master-Hone process developed by Nicol & Andrew, Ltd., Hillington, Glasgow, for the reconditioning, *in situ*, of such parts as the crankshafts of large marine engines, is now well established. With this process, the crankpins, side pins, scavenging pins, and main journals can be reconditioned, without the need for removing the crankshaft from the ship. The advantages which this system can offer to the engineering industry in general are now being more widely exploited, and an interesting example of the type of machine reconditioning work which can be undertaken in this manner is afforded by the set-up shown in the accompanying figure.

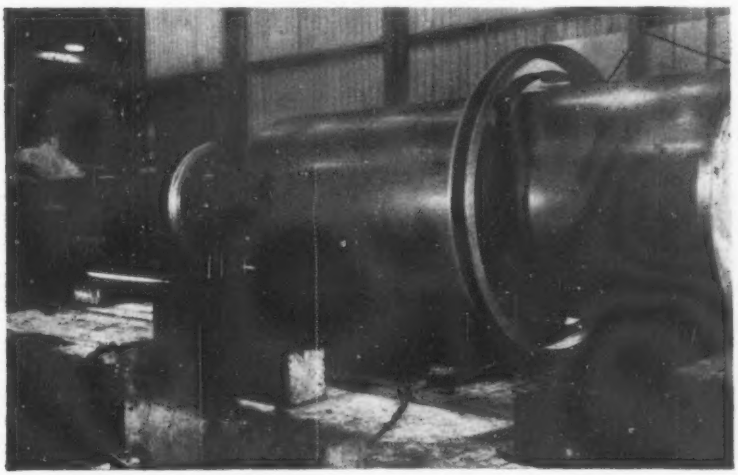
Here may be seen the main ram from a 2,500-ton Loewy extrusion press installed at the Redditch works of Reynolds T.I. Aluminium, Ltd. The ram has been withdrawn from the press, one frame of which can be seen in the left background, and a Master-Hone head has been applied to each of the two diameters. These diameters are 45 in. by 9 ft. 4 in. and 19½ in. by 9 ft. 4 in. long, and the weight of the ram is 30 tons. In order to restore the larger diameter portion to the required degree of roundness and parallelism, a total of 0·024 in. of metal was removed by the honing head, and in the case of the smaller diameter portion, which had suffered considerable wear over a number of years, 0·075 in. was removed. It was specified that, after regrinding, the two diameters must be concentric.

The heads are here shown without the drives, which consist of separate units complete with pulleys which are connected to the flanged rims of the honing heads by means of flat belts. A detailed description of this drive, and of the construction of the honing head was given in MACHINERY 85/1033—12/11/54.

Similar reconditioning operations were carried out on the twin main return rams of the same press. These rams also are of stepped form, having two diameters of 6 and 18 in. and an overall length of 23 ft. Again, it was specified that the two diameters on each ram should be concentric, and it was also essential that the finished diameters on the two rams should be identical.

The accuracy as regards size, parallelism and surface finish which can be obtained by this process was demonstrated by a test carried out on the piercer ram of the press. This ram is 20 in. diameter by 12 ft. long, and, after it had been reconditioned, a bronze ring, with a bore only 0·001 in. larger than the ram diameter, was pushed from one end to the other without any appreciable variation in resistance being detected.

It was estimated that by carrying out the reconditioning operations here described by the Master-Hone process, the press was idle for only one half the time which would have been involved if another method had been employed. In addition, the need for transporting the compo-



The main ram from a 2,500-ton Loewy extrusion press is here shown being reconditioned, on site, by the Master-Hone process. This ram, which weighs 30 tons, has two diameters of 45 and 19½ in.

nents to a reconditioning shop equipped with heavy-duty lathes was avoided.

It is stated that the same company have placed an order for a Master-Hone head for reconditioning the ram of a 5,000-ton Loewy extrusion press. This ram measures 57½ in. diameter by 12 ft. long, and the honing head will be the largest that has been built so far by the company.

Steplessly-variable Speed, Constant Horse-power Drive

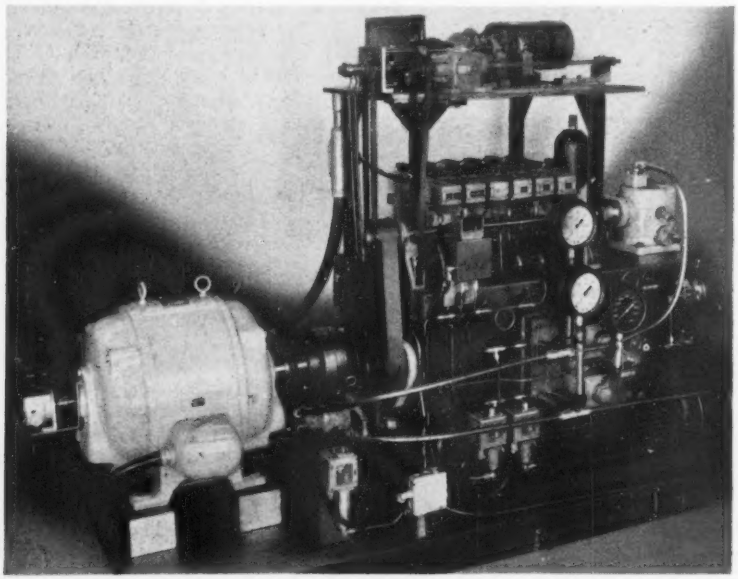
A power transmission that provides for stepless variation of output speed at constant horse-power has been developed by the Bullard Co., Bridgeport, Conn., U.S.A. While not yet ready for commercial application, the 40-h.p. prototype drive, here illustrated, has been used to give smooth speed changes on a vertical turret lathe over the range from 0 to 1,800 r.p.m.

During one test, the face of a large-diameter, steel disc part was faced from the periphery to the centre with constant cutting speed and at a constant horsepower. The smoothness of speed changing was demonstrated by suddenly reducing the cutting speed to 0 while taking a cut with a carbide tool, and then immediately increasing it to 300 ft. per min. No damage to the carbide tool or work was caused. It is stated, moreover, that extended overload tests, up to 75 h.p., caused no damage to the transmission. From no-load to full load, even with instant loading, there was no preceptible drop in rotational speed.

The new drive incorporates planetary differentials and two small, positive displacement, hydraulic units. Basically, two planetary differentials are required, which are interconnected so that during the operation of one, the other is preconditioned to take over the load. While such a basic drive can be built, the 40-h.p. prototype has two additional planetary differentials. With this arrangement, three separate but continuous ranges of speed are provided for the output shaft of the drive.

Hydraulically-operated clutches transfer the drive between the differentials. The clutch shifting sequence is controlled to ensure the engagement of one clutch before another is disengaged. All shifting take place with the clutch members synchronized. A servo mechanism ensures a positive speed relationship between the hydraulic units and the planetary differentials for shifting. Extensive prony-brake tests showed an 87 to 92 per cent operating efficiency for the 40-h.p. prototype in the range from 130 to 1,800 r.p.m.

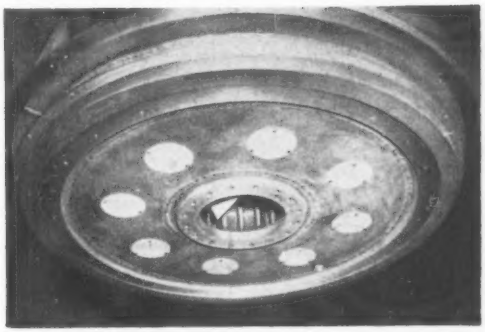
For development purposes, an electro-mechanical control system with solenoid-actuated valves was used for clutch operation. A compact, purely hydro-mechanical control system is now being designed, which will require a minimum of electrical equipment.



This Steplessly-variable Drive Delivers Constant Horse-power over a Wide Range of Speeds. The 40-h.p. Prototype Here Shown has been Successfully Applied to a Vertical Turret Lathe

Lapping Operations on Large Welded Pedestal Bases

By C. E. CALEBAUGH*



Although important advances are constantly being made in machining methods and equipment, the need for closer dimensional tolerances continues to present problems to production engineers. In some instances, tolerances usually associated with instrument work must now be held on parts of considerable size.

The Missile and Ordnance Systems Department of the General Electric Co., U.S.A., for example, maintain very high standards in the construction of tracking antennae for a long-range radar system. Flatness and parallelism of bearing surfaces must be held to ±0·00005 in. on weld-fabricated revolving pedestals and other parts measuring up to 85 in. diameter and weighing nearly 5,000 lb. Such accuracy is necessary for the correct functioning of the tracking equipment.

The use of a large lapping machine seemed to offer the best possibilities for obtaining the flatness and finish required on two 1-in. wide circular bearing surfaces on the base of the pedestal, one of 48 in. and the other of 14 in. diameter. The two surfaces are concentric, and must be in the same plane. Both surfaces can be seen in the heading illustration, which gives a view of the lower surface of the welded pedestal.

The machine employed is an 84-in. Crane Lapmaster, as seen in Fig. 1. Since the over-all diameter of the work is 85 in., it was necessary to modify the machine. The outside diameter of the table was increased to 85 in. and the inside diameter reduced to 10 in. to provide for lapping the smaller race. Additional clearance was obtained by moving the motor and mixing tank for the compound farther back from the table. To provide an environment suitable for precision machining and measurement, the builder recommended that the machine be installed in an enclosed air-conditioned area. This advice was followed, and the temperature of the room is controlled within 1 deg. F.

The chief problem encountered in connection with this operation was associated with the 4,920 lb. weight of the work. Instead of the

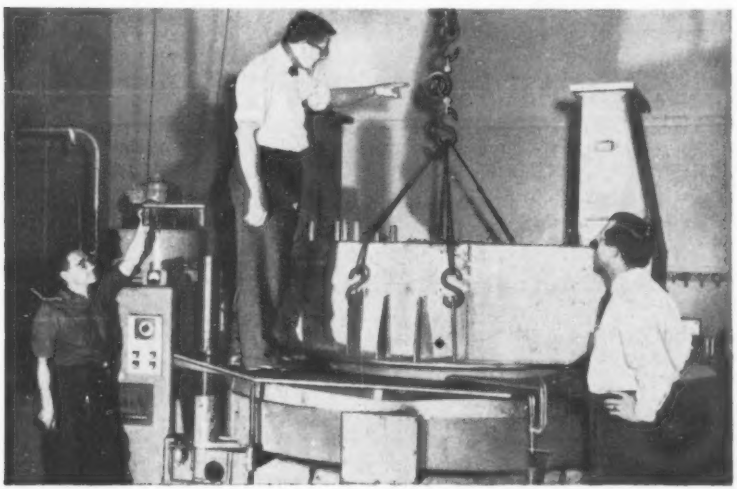


Fig. 1. During Lapping, the Greater Part of the Weight of the Pedestal is Carried by a Jib Crane

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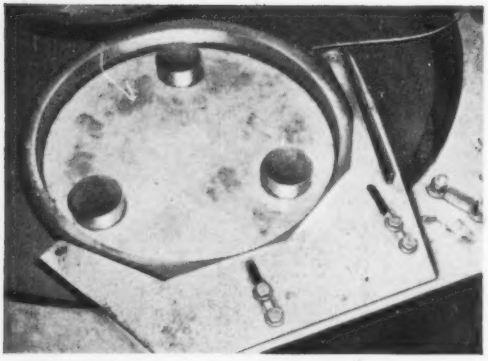


Fig. 2. The Truth of the Lapping Table is Maintained by Conditioning Rings which Revolve on Fixed Centres While the Table Rotates

generally acceptable lapping pressure of 3 lb. per sq. in., the pedestal would exert a pressure of 30 lb. per sq. in. on the table when in full contact. When the work is first set on the table, moreover, only three points are in contact, so that a considerably greater load per sq. in. would be applied. To overcome this difficulty, the work is supported from a jib crane, and a dynamometer on the crane hook indicates the weight carried by the table.

During lapping, the pedestal is positioned off-centre in relation to the table and is free to turn. The table rotates at 30 r.p.m. and exerts a braking action, so that the work does not reach a dangerous speed.

When lapping is started, a weight of 200 lb. is permitted on the table, for 1 min. As the amount of bearing surface area in contact with the table increases, greater weight is allowed for longer periods. When the surface which is being lapped shows full contact with the table, the work is raised and the table is trued with conditioning rings. Then the work is lapped for 1 min., after which both work and table are checked. This process is continued until the table remains true after the 1-min. cycle. When this condition is achieved, the part is ready for final inspection.

A lapping compound and vehicle were selected after considerable investigation. The compound, No. 1900 aluminium-oxide grit, produces a surface finish of 4 micro-inches, and the vehicle was supplied by the builders of the Lapmaster (the Crane Packing Co.). Best results were obtained with a mixture of ½ lb. of the compound to one gal. of the vehicle. During lapping, the mixture flows from the tank through tubes on to the table, where it is distributed uniformly. Radial grooves in the table serve as collectors for spent grit.

The conditioning rings, made from the same alloy cast iron as the table, revolve about their own axes as a result of the table rotation, but must not themselves rotate with the table. For this reason, each conditioning ring is confined in a yoke which is fastened to a rim plate encircling the table, as seen in Fig. 2. Truth of the table is checked by lapping the three small brass discs seen inside the ring, and inspecting them with an optical flat.

(For most lapping applications, the work is small enough to be contained within the rings, so that table truing proceeds simultaneously with the lapping. This combined action is entirely practical since the rings wear the table surface faster than does the work, and thus maintain its accuracy. In Fig. 3, for example, the base of a bearing cap is shown being lapped inside a conditioning ring.)

Before lapping is begun, it is necessary to inspect the table sectors to make sure that they are free from residual magnetism. Experience has shown that even slight magnetism is detrimental to the attainment of flatness. Most magnetism is picked up from parts that have been surface ground in magnetic chucks and not subsequently demagnetized completely.

A 60-cycle demagnetizer is normally adequate. On account of the precision required for the bearing surfaces, however, each sector was demagnetized individually by placing it in a 44,000-ampere-turn direct-current solenoid. The direction of magnetism was alternately reversed to sucessively lower values until the residue was negligible.

To enable the flatness of the bearings to be finally checked, a large laboratory-grade granite

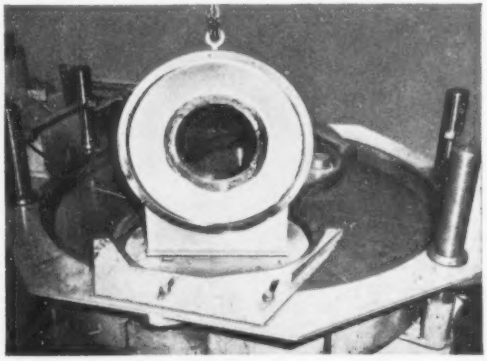


Fig. 3. Since the Surface of this Bearing Cap Fits Inside the Conditioning Ring, the Machine Table is Trued while Lapping is in Progress

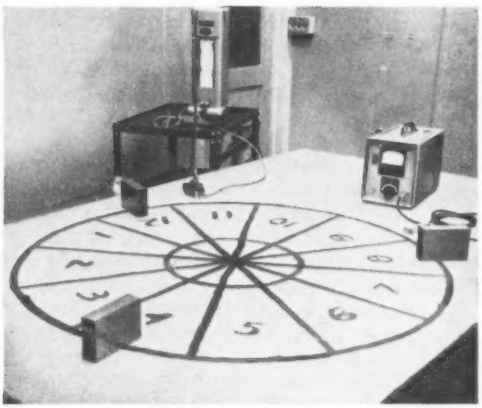


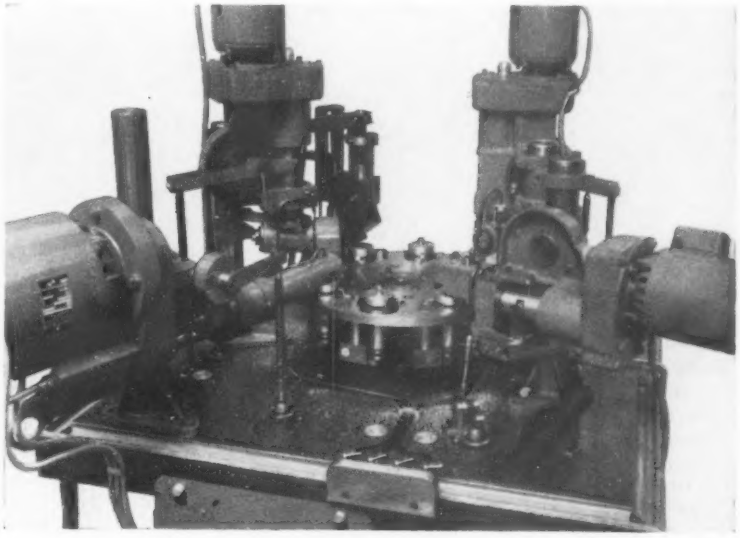
Fig. 4. Flatness of the Bearing Surfaces is Compared with that of a Surface Plate by Means of a Sheffield Air Gauge

surface plate was obtained. It was lapped to the best possible flatness by the supplier in his plant, and later, when installed in the same room with the Lapmaster, it was inspected with a Profilometer and found to be within 0·00015 in. over a 48-in. diameter area while carrying a 4,700-lb. load.

The surface plate was laid out as a large wheel with twelve spokes, as seen in Fig. 4. Both bearing surfaces were then compared with the surface plate, using a Sheffield air gauge having a 5,000 to 1 amplification. By means of the two methods—comparision with the surface plate, and inspection of the brass discs with an optical flat—it can be determined whether flatness has been attained to within ±0·00005 in. How closely the surface approximates to a true plane can be determined only when more precise checking equipment becomes available.

Machining Electrical Contacts on a Compass Mark VII Automation Base

In the accompanying illustration is shown a typical set-up, on a Compass Mark VII automation base, which was demonstrated at the recent Production Exhibition at Olympia, by Bristol Repetition, Ltd., Feeder Road, Bristol, 2. The machine is tooled for secondary operations on small brass electrical contacts, of stepped tubular form, which were produced on an automatic, and it has eight stations. At the first station, seen on the further side of the machine, the components are placed by hand in a cam-operated collet chuck, in which they are positioned at the required height by a stop. As the table is automatically indexed, by the ratchet wheel



On this Special Machine Constructed from a Compass Mark VII Automation Base and Various Standardized Attachments, Milling, Drilling, Tapping and Slotting Operations are Performed on a Brass Contact in a 2-sec. Cycle

beneath it, the newly-loaded component is moved in a clockwise direction to station (2) at which there is a vertically-moving spindle fitted with a ¼-in. diameter, 6-fluted end mill. This tool is employed to mill a ¼-in. wide by ⅜-in. long flat on one side of the part, and at the next indexing motion the work is carried to an idle station.

Station (4), in the right foreground of the illustration, is equipped with a drilling head with a 0·203-in. diameter drill, which produces a tapping size hole for a $\frac{3}{16}$-in. Whitworth tap in one side of the part. The cam-operated feed arrangements for this head, and the linkages and levers whereby the movement is transmitted from the camshaft beneath the table, may be clearly seen. Another idle station follows, and the work is subsequently indexed to station (6) in the left foreground. Here, the spindle is fitted with a $\frac{3}{16}$ in. Whitworth tap which is fed at the correct rate in relation to the speed and pitch of the thread. At station (7), a horizontal spindle fitted with a 2¼-in. diameter, fine pitch tooth milling cutter, of $\frac{1}{32}$-in. thickness, is fed down to cut a slot $\frac{7}{16}$ in. deep.

Finally, at station (8), the collet jaws are automatically opened by a cam, and an automatic unit lifts the part out of the collet. This unit, incorporates two fingers which are opened as they are lowered towards the part, and then closed to grip it before being raised. As the component is lifted, a linkage causes a metal chute to move forward beneath it, and when the fingers are subsequently opened the part falls on to the chute and is deflected into a box. The cycle time for these operations is of the order of 2 sec.

Semi-automatic Cutter-conveyor Installation for Steel Billets

Substantial savings in the time required for the preparation of large steel billets for the furnace has been made possible by the use of the new semi-automatic flame-cutting unit seen in the accompanying illustration. Built by Weldall & Assembly, Ltd., Stourbridge, for W. Wesson & Co., Ltd., Wednesbury, the installation comprises two power-driven conveyors leading to a gravity conveyor, and an automatic oxy-acetylene straight-line cutter.

When each slab of steel contacts the gate-stop on the second powered conveyor, both conveyors are stopped automatically, and the steel slab is cut to a predetermined length. Then, the operator presses a button, to raise the gate by pneumatic power, and the second powered conveyor transfers the cut billet to the gravity-conveyor section. Next, an air valve is re-set by the operator, and the gravity-conveyor is tilted, as shown, to discharge the billet on to a truck or another conveyor. By tilting the gravity-conveyor in the opposite direction, the smaller off-cuts can be discharged. A safety-catch ensures that in the event of an air failure, the tiling conveyor is automatically locked in the horizontal setting.

Billets are advanced, normally, at approximately 30 ft. per min., and the installation incorporates automatic controls which actuate the first conveyor, to deliver succeeding slabs for cutting, as soon as a billet has passed through the cutting section.

Semi-automatic Installation Built by Weldall & Assembly, Ltd., for Feeding and Cutting Steel Billets. After Cutting, the Billets are Discharged by means of the Tilting Conveyor Section

Taylor-Hobson Engraving and Routing Machines

A recent addition to the well-known range of engraving machines made by Taylor, Taylor & Hobson, Ltd., Leicester, is the type JH, shown in the accompanying Fig. 1, which incorporates an improved design of pantograph and other features, and is noteworthy for its high precision and robust construction. The design has also been adapted for the type JR high-speed routing machine, which incorporates the same column and work table unit, as seen in Fig. 2. Measuring 20 by 10 in., the T-slotted work table has screw adjustment by hand of 12 in., longitudinally, transversely and vertically. The table feed screws are enclosed, to prevent the ingress of swarf, and the feed dials are graduated in units of 0·001 in. for the vertical, and 0·002 in. for the longitudinal and transverse, movements.

TYPE JH ENGRAVING MACHINE

The pantograph of the engraving machine incorporates high-precision, pre-loaded ball bearings and provides ratios from 1 to 1 up to 50 to 1, the area covered by the cutter at 1 to 1 ratio being 8⅞ in. square, 9⅝ in. diameter, or a rectangle up to 7⅛ by 14¾ in. At 50 to 1 ratio, a square or circle of ⅜ in. can be covered, or a rectangle of ½ by ¼ in. With the cutter in the central position, the maximum distance from cutter to table, when using the maximum throat depth, is 8½ in. A range of rectangular and circular copy holders is available for a variety of requirements. The dynamically-balanced cutter spindle runs in ball bearings of high precision and the drive is taken from a ½-h.p. motor, carried on anti-vibration mountings, through a countershaft and stepped pulleys which provide eight speeds from 3,000 to 18,000 r.p.m.

Transmission to the countershaft is by elastic belt, and from the countershaft to the spindle by a round cotton belt. Tensioning of the spindle belt is effected by means of an idler pulley carried on an arm which is mounted in a rubber bush. A push-rod brake, which can be applied to the periphery of the countershaft pulley, is provided for rapidly stopping the spindle. Parallel-shank cutters up to ⅜ in. diameter, as well as Taylor-Hobson taper shank engraving cutters can be employed, and in addition to normal engraving work the machine can be employed effectively for producing a wide variety of parts, from the solid, if required, by the use of simple templates.

A vertical movement of ¾ in. is provided for the spindle quill, and the feed is applied by rotating a knurled cap carried on a multi-start screw. The quill is spring-loaded upwards, and the top of the feed cap bears against a downwardly-projecting thrust peg in the frame which carries the spindle assembly, so that a backlash-free movement is obtained. A locking handle enables the spindle to be clamped in any position, and engraving and milling operations can then be carried out at a fixed depth.

The machine can also be employed for normal light-duty milling operations by the use of a detachable bracket, which is fastened by screws to the fixed head of the pantograph, and clamped on to the thrust peg on the spindle carrier, so that the pantograph linkage is immobilised. Longitudinal, transverse and vertical feeds are then

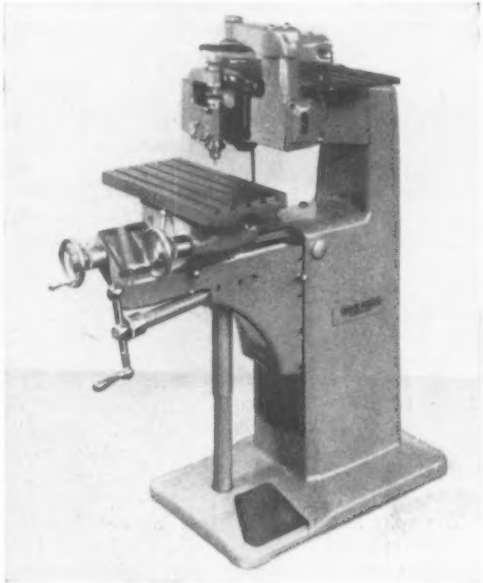


Fig. 1. Taylor-Hobson type JH precision engraver-miller

applied, as required, by means of the table hand wheels. In addition, the spindle quill can be fed vertically through the full distance of ¾ in. by rotating the knurled cap.

This milling bracket can also be employed to hold a thrust pad, ranging up to 2½ in. diameter, with a profiled lower surface, when engraving and milling operations are to be carried out on curved workpieces. For this purpose, the normal thrust peg is removed from the spindle carrier, and the profiled pad in the bracket is engaged by a stylus point on a special knurled feed cap. The maximum depth of contour that can be engraved by this method is ½ in.

A cam-type feed mechanism, actuated by a finger lever, can be fitted in place of the knurled cap, this arrangement being particularly suitable for use on light engraving where a lever feed is preferred. This lever provides a coarse feed of ¾ in., together with a fine feed of approximately 0·10 in. The lever feed arrangement, in conjunction with a presser foot which bears directly on the work, can also be employed for engraving on uneven surfaces.

Other equipment available for the machine includes a universal dividing head with a 6-in. diameter faceplate and a 12-in. diameter rotary table. Extension tables and extension bars can be provided for handling large workpieces, and the Taylor-Hobson Javelin and resistance etching units can be used on the machine.

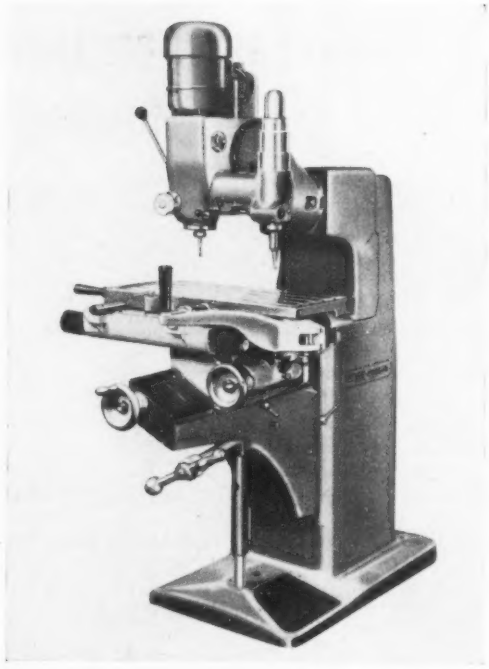


Fig. 2. Taylor-Hobson type JR high-speed routing machine fitted with a stylus and duplicator table

TYPE JR ROUTING MACHINE

The routing machine, shown in Fig. 2, is fitted with a universal spindle head which can be swivelled through 45 deg. to the right or left, 60 deg. forward, and 30 deg. backward, the latter movement being limited to 15 deg., however, when the stylus tracer arm is fitted. The throat depth of the machine is 16½ in.

Drive is taken from a ½-h.p. motor, carried on anti-vibration mountings, through paired cotton belts to an intermediate pulley, and from the latter to the spindle. Eight speeds from 500 to 18,000 r.p.m. are thus provided, and a push rod brake, acting on the motor pulley, is incorporated, also a belt tensioning device. The motor and all the pulleys are dynamically balanced to ensure smooth running, and the spindle is mounted in high-precision ball bearings.

The spindle quill travel is ¾ in., and fine feed can be applied by a knurled, graduated knob through worm reduction gearing, pinion and rack. With the worm disengaged, coarse feed may be applied by a hand lever. Taylor-Hobson taper-shank engraving cutters may be used, also parallel-shank cutters up to ¾ in. diameter, mounted in collets.

A detachable 20- by 12-in. T-slotted duplicator table, seen fitted in Fig. 2, enables the machine to be employed for performing a variety of profiling operations under the control of a 1 to 1 ratio master which is engaged by a stylus carried on the spindle head.

The table is carried on ball-bushes moving on lubricated round slide bars which are protected by bellows, and an area of 4 by 3 in. can be covered by this floating motion. Movement of the table is effected by a pantograph linkage through a hand lever which provides a 3 to 1 mechanical advantage, and an additional handle is fitted on the left of the table to facilitate control of the movement. The stylus rod is coupled directly to the spindle quill, and moves vertically with it. In addition, an independent fine adjustment through a distance of 2½ in. is available. The distance between the cutter spindle and stylus axis is 9 in., and, when the duplicator table is fitted, the vertical adjustment of the knee on the machine column is 8½ in.

Expansion of the Hereford Works of Henry Wiggin

A long-term expansion scheme of considerable magnitude is at present being undertaken at the Holmer Road, Hereford, works of Henry Wiggin & Co., Ltd., manufacturers of a wide range of nickel-based alloys. The erection of the original works at Hereford was started for the Ministry of Supply, in 1951, and the plant installed comprised a 5,000-ton Loewy extrusion press, two 3,500-lb. induction melting furnaces, and a number of hot and cold sheet rolling mills. The first billet was extruded in 1954, and two years later the company purchased the works from the Ministry of Supply with the objects of concentrating all production in one plant, and, at the same time, expanding and modernizing all the facilities. Work is proceeding in three stages, the first of which has already been completed, and by 1965 is it planned to have increased the covered area from the present 7 acres to a final total of 25 acres. The buildings are of the most up-to-date design and construction, and an indication of the size of the site is afforded by the fact that when the development plan has been completed there will still be another 27 acres remaining.

The development is known by the company as the "M and C" (modernization and concentration) plan, and the ultimate object is to bring all the activities at present carried out at the Glasgow and Birmingham factories to the Hereford site. The work involved in the first stage of the plan, namely transferring all the major melting processes from the Birmingham works to Holmer Road, was treated as a separate undertaking, and was completed without interrupting production at either of the two factories. Stages two and three, however, are overlapping in certain respects, but, again, it is planned to carry them out without any interruptions in production. The total number employed at the three factories at the present time is approximately 2,800, and when the plan has been completed, and all the company's activities are concentrated at Hereford, it is anticipated that the labour force will be in the region of 3,000.

The production facilities at Hereford at the end of the first stage of the development are divided into five main sections, each with ancillary departments. For melting processes, there are now three Birlec 3,500-lb. capacity induction furnaces, each of which can be fitted with an interchangeable body of 1,500-lb. capacity. In addition, there are two Birlec direct-arc furnaces of 3-ton capacity, also fitted with interchangeable bodies, to enable different alloys to be handled without the need for frequent changing of the furnace linings. For casting the ingots, the Durville process; top and bottom methods; and Sheppard water-spray cooled

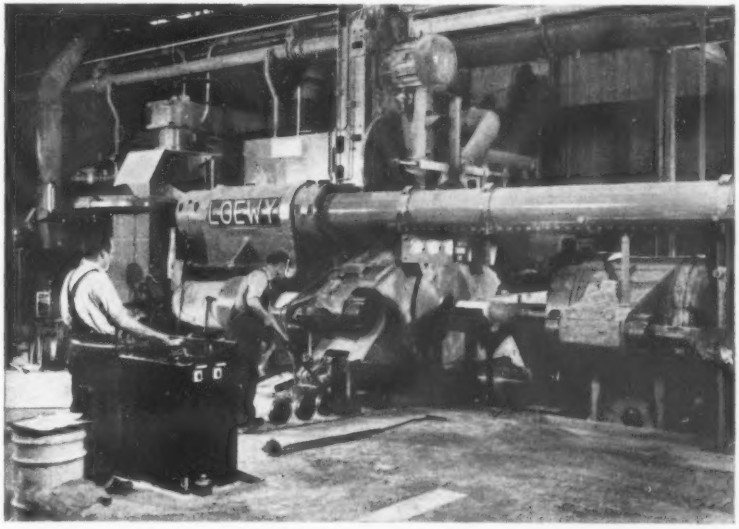


Fig. 1. General view of the 5,000-ton Loewy extrusion press installed at the Holmer Road, Hereford, works of Henry Wiggin & Co., Ltd. This press, which is employed for the extrusion of a range of nickel-based alloys, is operated in conjunction with the Ugine-Sejournet method of glass lubrication

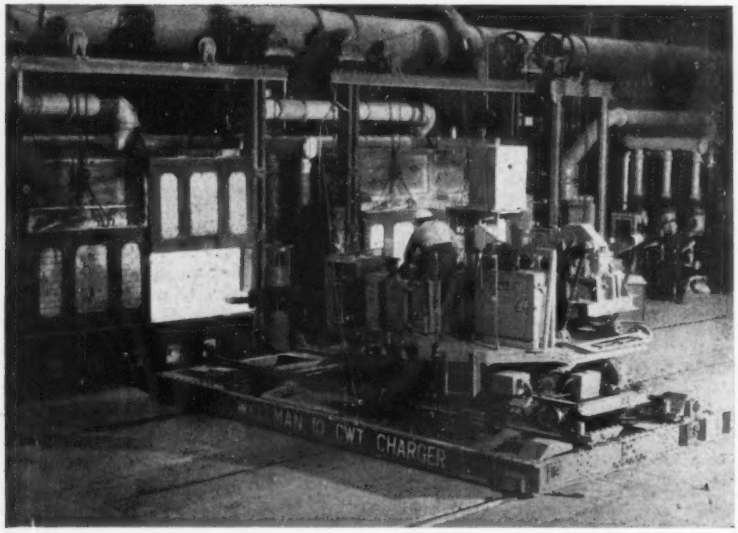


Fig. 2. This Wellman charger, is used to transfer the heated billet from the furnace to a trough leading directly to the Loewy press

pig casting machines, are mainly employed. A Birlec-Detroit rocking arc furnace, and a number of crushers, ball-mills, sieves, and a Wilfley table are installed in the metal recovery plant.

The machining department is divided into two sections, in one of which cast ingots are machined for subsequent extrusion, and forged billets are prepared for despatch, and in the other, extruded bars are either peeled, turned, or centreless-ground, according to requirements. Prominent in the extrusion section of the plant is the 5,000-ton Loewy extrusion press seen in Fig. 1. This machine was installed in 1954, and is employed for extruding nickel-based alloys into round bar, for the production of rotor blades by subsequent pressing or forging operations; into rectangular section, for direct machining of such parts as stator blades; and into rectangular section, for subsequent hot or cold rolling. For rod rolling, the material is extruded to a square section.

This Loewy press is operated in conjunction with the Ugine-Sejournet method of glass lubrication, which was described in MACHINERY, 85/471—3/9/54. To apply the glass to the sides of the billet, a glass mat is laid in the bottom of the delivery trough which connects the press to a battery of four Wellman furnaces. These furnaces are arranged in a row parallel to and behind the extrusion press, and are served by the Wellman charger seen in Fig. 2. As the billet proceeds down the delivery trough it passes over the glass mat, which rolls round and adheres to the red-hot surface. To provide lubrication for the entry side of the extrusion die, a mop of glass wool is loaded, by hand, into the die chamber and pressed home with a ram-rod.

The extrusion dies are at present made from 10 per cent tungsten steel, but experiments with dies of Nimonic 90 have yielded encouraging results, and it is anticipated that eventually all dies will be made from this material. Depending on the type of alloy being extruded, and the shape of the section, the life of the die varies from 30 to 50 extrusions.

In its present stage of development, the cold rolling section includes a 4-high, 300-h.p. Davy and United reversing mill; two Bigwood stretching machines, for sheet up to a maximum thickness of ¼ in.; two Birlec continuous annealing furnaces; and two Bronx shears, for sheet up to ⅜-in. thick. Auxiliary equipment for this section includes salt baths, acid pickling tanks, and shot blasting plant.

The metallurgical laboratories at the Holmer Road works have two main functions: firstly, the examination of samples from each production batch to ensure strict conformation to the specifications for chemical analysis and mechanical and high-temperature properties; and, secondly, the initiation and supervision of research aimed at improving both the range of alloys and the production processes, with emphasis on the latter.

NEW FIRST AID DRESSING. A new emergency first aid dressing is now being marketed by Robert Whitelaw (Newcastle), Ltd., 44 Great North Road, Newcastle-upon-Tyne, 2. Known as the Klintex, the pack is particularly intended for use in circumstances where water is not readily available, and contains a quantity of antiseptic cleansing fluid in a plastics bottle. The dressing is covered by a sterile paper cover, and comprises cotton wool, gauze, also a bandage, all contained in a cardboard container. It is generally similar to the No. 13 mines dressing.

Grinding Machine Demonstration

Charles Churchill & Co., Ltd., recently staged demonstrations, at their showrooms at Coventry Road, South Yardley, Birmingham, of surface, cylindrical and internal grinders made by Churchill Machine Tool Co., Ltd., Broadheath, Manchester, for whom they are the sole agents.

One of the machines shown in operation was the latest type NB, 18- by 6-in., hydraulic surface grinder, the wheel-head of which has special provision for the mounting of Diaform type 5/1 and type 5/2 template controlled profile wheel dressing attachments [L. M. Van Moppes & Sons (Diamond Tools), Ltd.]. Precision grinding of intricate profile shapes for form tools and inserts for lamination dies of high-speed steel was demonstrated, and the machine was fitted with the type 5/1 attachment as shown in the illustration. The pantograph mechanism of this attachment gives a reduction ratio of 10 to 1, and enables profile shapes up to ⅝ in. deep to be dressed on 1-in. wide wheels. A full description of the type NB surface grinder will be published in a forthcoming issue of MACHINERY.

A new wheel-head mounted profile dressing attachment was incorporated in a type BW, 10- by 36-in., cylindrical grinder, which was set up for grinding, by plunge feeding, a 7-in. long stepped shaft with a maximum diameter of 1¾ in. The new unit enables profile shapes to be formed on grinding wheels up to 6 in. wide, and the dressing slide is traversed, at steplessly-variable speeds, by a screw, driven by a small electric motor which is interlocked with the work-head driving motor. The diamond holder is carried at the lower end of a spring-loaded plunger, vertical movement of which, for producing the required form on the grinding wheel, is controlled by a template. Vertical adjustment of the diamond holder, for applying the cut after the completion of each pass, are made in increments of 0·001 in. by a knob-operated "click" feed mechanism built into the unit.

For the demonstration, the machine was also fitted with the M.P.J. electro-sizing gauge, which, as was explained in MACHINERY, 87/71—8/7/55, is specially designed for use on Churchill auto-sizing plain grinders with hydraulic wheel-head control and diminishing feed. This equipment comprises, essentially, a dial indicator caliper gauge with a built-in control switch, which is mounted on the wheel guard and is swung into position by hand at the beginning of the grinding cycle. Reduction of workpiece diameter as grinding proceeds, is shown by the dial indicator, and at a pre-determined point of the cycle, the in-feed is stopped, and the wheel-head is then caused to dwell for a pre-set period, which is adjusted by a timer on the bed. A signal lamp on the wheel-head is illuminated during the dwell period, and at the end of this stage, the grinding wheel is automatically withdrawn clear of the work.

A type AW Fulcro-Sizer 6-in. swing fully-automatic plain grinder was set up for grinding a ¼-in. diameter by 1⅞-in. long portion on a hardened steel nozzle piece for a fuel valve. With the Fulcro-Sizer automatic system, the work is fed to the grinding wheel by tilting the table, instead of advancing the wheel to the work, and is claimed to afford an accuracy of ±0·0005 in. on long runs of components, without the need for sizing gauges.

Other machines which were demonstrated comprised of the type OSB 42- by 10-in. surface grinder, the type PBW 12- by 36-in. universal grinder, and the type HBM automatic sizing internal grinder.

Churchill type NB surface grinder with a Diaform dressing attachment mounted on the wheel-head

Watson Industrial Microscope

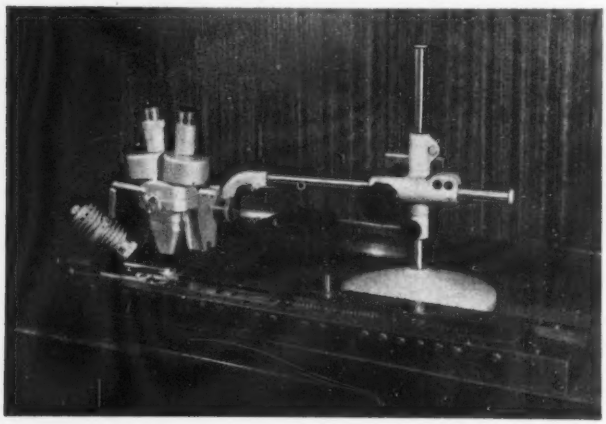
At an exhibition of optical instruments for industry and science, staged recently at the works of W. Watson & Sons, Ltd., West End Lane, Barnet, Herts., examples from their recently-introduced range of industrial stereoscopic binocular microscopes were demonstrated. The various set-ups included typical engineering applications, which afforded evidence of the visual advantages of 3-dimensional viewing, and the reduction in fatigue that is ensured by the use of the binocular system. Among the subjects of these set-ups were very small transistors, an elaborate radio-valve assembly, and a set of broaches from a machine in the company's factory.

The basic instrument of the series, which gives a wide field of view over a range of magnifications from 3× to 140×, is mounted on a simple cast foot. This foot is small, to allow as much clear space as possible beneath the lenses, and specimens up to 2¾ in. thick can be accommodated. Two types of binocular heads can be supplied in one of which the eyepieces are arranged vertically, and the other, inclined at 45 deg. Three types of nosepieces are available, which will carry one, two, or three objectives. The multiple nosepieces are of the rotating type, and when mounted, the objectives are partly pre-set, so that very little re-focusing is required in changing from one magnification to another. Focusing is effected by means of large finger-wheels on either side of the stand, through a diagonally-cut rack and pinion arrangement.

To render the instruments as adaptable as possible, there is a comprehensive range of alternative mountings, and the standard horseshoe base is readily removable. These alternative mountings include a bench clamp, with provision for tilting through 55 deg.; a horizontal bar on a heavy rectangular base, on which the instrument can be tilted and traversed; a column and arm stand, with a large rectangular base-plate, on which the instrument can be raised, lowered, tilted, traversed along the arm, and swung about the column; a similar stand, with a bench-type clamp; and a column and arm stand, on a heavy circular base, with a rack and pinion motion on the arm. This latter unit, which is also available with a bench-type clamp, can be used to traverse the instrument over a large unobstructed area of the bench and work. Shown in the accompanying figure, this stand was employed for the broach checking set-up mentioned, and the usefulness of the rack and pinion motion, for traversing the instrument from tooth to tooth, was apparent.

Other equipment on display included examples from the firm's range of metallurgical microscopes, the Holophot photomicrographic apparatus, a phase contrast microscope, "zoom" and anamorphic lenses, galvanometer mirrors, and the British-type konimiter. Designed in collaboration with the Ministry of Fuel and Power, the latter is a compact, portable instrument, intended for the examination and estimation of the number of dust particles in the air. Briefly, it comprises a spring-operated pump, which draws a measured volume of air through a jet, and directs it on to a glass plate coated with a special glycerine-base adhesive.

Dust particles which are trapped by the adhesive are examined through an incorporated microscope, and the particle size and quantity are determined by reference to an eye-piece graticule. The circular glass plate is rotatable, and is divided into 30 numbered sectors, each of which serves to check one air sample. It can be used repeatedly, by cleaning off the surface and re-coating it with the adhesive.



Watson industrial stereoscopic binocular microscope, set up on a long-arm stand for the examination of broach teeth

News of the Industry

Manchester and District

CRAVEN BROTHERS (MANCHESTER), LTD., Reddish, Stockport, have in hand a wide range of heavy machine tools for both the home and export markets. Recent orders cover vertical boring and turning mills of the new design with electrically-driven feed motions, in 5-, 6- and 7-ft. sizes, also standard machines in the 8- to 12-ft. range. One of the 5-ft. mills is to be provided with electrically-operated profile copying equipment. Railway machine tools recently ordered include 3-ft. 3-in., 5-ft. and 5-ft. 6-in. wheel lathes, and solid wheel trepanning machines. Orders for heavy-duty centre lathes are well maintained, including machines with electric profile copying equipment, and roll-turning lathes of 17- and 22½-in. centres.

Among other plant recently ordered we may note a bar skimming machine; a rotary head tube parting machine for tubes up to 26 in. outside diameter; a 20- by 6-ft. square planing machine; a plano-milling machine for handling work up to 8 ft. wide by 6 ft. high; a 78-in. papermill-type roll grinding machine; and a number of special face milling machines.

In the works our attention was drawn to vertical boring and turning mills in progress, of 5-, 7-, 10- and 16-ft. diameter capacities. One of the latter machines is being equipped with a 14-ft. diameter table, and another has an independently-driven central boring head, in addition to the two normal cross-rail rams and saddles. A papermill-type roll and cylinder grinding machine in progress will have a capacity for work from 6 to 60 in. diameter and up to 32 ft. long, and will be equipped with dust extraction plant. Among the lathes in hand may be mentioned a 4-ft. railway wheel type with power-operated axial adjustment of the two spindles and faceplates to facilitate the engagement of the drivers; two 36¼-in. centre lathes provided with auxiliary boring bar saddles and electrically-driven profile copying equipment; a 60-in. centre lathe; and a 36/48-in. double-ended sliding, surfacing and screwcutting lathe with an overall length of 117 ft.

Other machines in various stages of construction include two locomotive crankpin re-turning and quartering machines; a 4¾-in. spindle, table-type, and a 7½-in. spindle, floorplate-type, horizontal boring machine; and a 24- by 10- by 8-ft. planing machine. In the temperature-controlled gear hobbing machine department we noted a 16-ft. moving-column-type turbine gear hobber; a 90-in. travelling-table-type turbine gear hobber; a 72-in. travelling-table-type universal commercial gear hobber; and a 42 in. spiral bevel gear generator.

Various Craven machine tools, which have been built on a batch production basis, are now available from stock or for very early delivery. Particulars of these machines are given in a recently-issued leaflet.

We hope shortly to describe a horizontal-type turbine pinion hobbing machine which has recently been supplied to the Empresa Nacional "Bazan" de C.N.M., S.A., Madrid, and is complementary to a Craven 16-ft. vertical-type turbine wheel hobbing machine. It will cut high-speed turbine pinions from 6 to 39 in. diameter by 9 ft. face width, with an overall length not exceeding 12 ft. 6 in.

The main drive is transmitted from a 10 h.p. constant-speed reversing motor through reduction gears and pick-off change gears, and there are ten hob speeds ranging from 10 to 80 r.p.m. The maximum and minimum centre distances between the hob and work spindle are 24¾ and 3½ in.

CROWTHORN ENGINEERING CO., LTD., Reddish, Stockport, have a number of 7½-in. centre lathes in hand, some of which are destined for technical college use. We also noted several of the new 10½-in. centre HD lathes, and larger machines include a 12½-in. centre lathe on a 17-ft. 9-in. long bed for the National Iranian Oil Co., Ltd., and an 18-in. centre by 27-ft. 9-in. long, gap-bed, lathe for Birmingham. A 32-in. swing surfacing and boring lathe on order is destined for a cable manufacturing firm. Export orders have recently been received from Holland, Norway, South Africa, New Zealand and Canada. The latest addition to plant is a Union 4-in. spindle horizontal boring machine. Activities of associated companies include the production of a variety of mechanical gymnasium equipment and low temperature refrigerators. Orders for the latter are in hand for the Ministry of Works, technical colleges, aircraft manufacturers, Pakistan, and British West Indies.

J. HALDEN & CO., LTD., Reddish, Stockport (head office—8 Albert Square, Manchester), report an expanding demand for drawing office materials and instruments. We hope shortly to

describe the firm's recently-developed Uniref combined drafting and reference table. Some of the company's latest products will be on view at the Public Works Exhibition to be held at Olympia, London, from November 10 to 15.

JIGS & TOOLS (STOCKPORT), LTD., Stockport, are steadily occupied with the production of jigs and fixtures for the aircraft industry, and a variety of form grinding work, some of which is being undertaken for the cutlery trade. An associated company has recently been formed, in conjunction with R.G. Boardman (Tools), Ltd., 44 Summer Road, Birmingham, to be known as R. G. BOARDMAN TOOLS (CHESHIRE), LTD., for handling all types of engineers' supplies and particularly for distributing Cleveland drills and other tools in the North West of England.

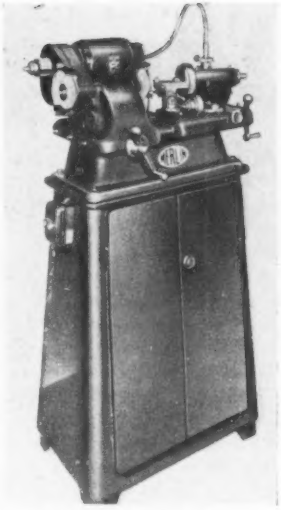
RHODES, BRYDON & YOUATT, LTD., Stockport, are producing a wide variety of pumps for customers both at home and abroad. These pumps include small, medium and large-capacity units of both the vertical and horizontal types. Orders in hand cover stainless steel pumps, high-lift pumps, centrifugal impeller, self-priming pumps, and vertical Mopumps for handling low melting point metals and molten inorganic chemicals.

H. B.

Servicemaster R2 Injection Grinder

The latest design of Servicemaster type R2 precision grinding machine made by the Merlin Engineering Co., Ltd., Salterhebble, Halifax, Yorks., and shown in the accompanying illustration, is to be displayed on the company's stand at the forthcoming International Motor Show. Introduced to meet the demand for a low-priced machine suitable for servicing most types of injectors employed on the currently popular smaller sizes of diesel engine, the R2 is basically similar to the well-established Servicemaster. The wheel-head slide is mounted at the left-hand end of a substantial cast base, and can be adjusted transversely by means of the ball-handle. On this slide, the wheel spindle is carried in specially designed, pre-loaded, double angular-contact ball bearings, which are efficiently sealed against dust, and is driven from a ½-h.p. motor through a flat belt.

At the left-hand end of the motor spindle is fitted a Jacobs type chuck which provides for lapping nozzle seatings, after a lap of suitable angle has been ground on the machine. The right-hand end of the motor spindle is connected by a flexible shaft drive to another spindle in a housing at the right-hand end of the base. This housing is mounted on a slide which can be moved by a handwheel in a longitudinal direction, towards or away from the grinding wheel. The slide also carries a pedestal, on which is mounted a block with a shallow V-groove in one vertical face, and this block can be adjusted, with the aid of a scale and vernier, to any angle between 52 and 68 deg. within 1 min. of arc.



The new Merlin R2 Servicemaster diesel injector servicing machine

When a lap or needle seating is to be ground, the block is set to the required angle and the component is placed in the V-groove where it is retained, and driven for the grinding operation, by means of a soft rubber contact wheel on a shaft which is coupled to the right-hand spindle. The machine base is supported on a well-made steel cabinet with shelves for the storage of tools and attachments.

King Materials Handling Film

Entitled "Kings in Industry," a 16-mm. sales-promotion film dealing with the activities of Geo. W. King, Ltd., Stevenage, Herts, who are specialists in the design and production of mechanical handling equipment, was recently shown at the British Council Film Theatre, Hanover Street, London, W.1.

Attention is drawn to the wide variety of products and there are shots showing pulley blocks and hoists, which are made with capacities from 200 lb. to 13½ tons; electric overhead travelling cranes; and the Ski-Wracker stacking unit for manipulating loads in confined spaces. Normally pedestrian-controlled by means of a pendant push button station, this equipment comprises an overhead travelling crane with a rotatable telescopic mast suspended below the trolley. At the lower end, the mast can be fitted with a variety of handling units, such as a fork-lift type carriage; a boom and hook; or an assembly with adjustable centres between which rolls of strip steel, for example, can

be held. Provision is made for mounting a driving cab at the base of the mast, if required.

Views are then presented of conveyor systems of the under-floor and overhead types for towing trucks in large factories and stores, particular mention being made of a 7,000-ft. long Under-tug conveyor which circulates 400 trucks through a large warehouse at a U.S.A.F. base in Britain.

The final—and longest—section of the film is devoted to plant installed at the Longbridge works of the Austin Motor Co., Ltd., where some 17 miles of King conveyors are in use. Among interesting features of the installation are patented Stanrun overhead chain conveyors whereby components are automatically selected, conveyed, stored until required, and then fed to the engine assembly shop. The components are carried by trolleys which are moved by, but are not attached to, the chains, except on inclined lengths of the conveyors, where a positive drive is automatically engaged. Movement of trolleys from one conveyor to another in the works is effected by air-operated indexing transfer units.

With a commentary spoken by Mr. John Snagge, the film runs for 24 min. and copies are available on loan, free of charge.

B.S.I. Annual Report 1957-8

The annual report of the British Standards Institution for 1957-8, which has recently been issued, affords ample evidence of the continued growth and importance of the work undertaken. In particular attention may be drawn to the enlarged scope and significance of international collaboration on standards, and the increase in public recognition of the Institution's activities. During the year, some 2,800 committees held a total of 4,320 meetings and the number of new or revised standards published exceeded 250. It may also be noted that the sales of standards rose to a new record total, and the number of subscribing members from 9,000 to nearly 10,000. The growth in membership, which was particularly welcome, was the largest for any year so far, and it is also reported that a considerable number of the existing members agreed to pay increased subscriptions.

A general report includes sections on such matters as revision of byelaws, conference of standards officers, certification marking, B.S.I. export panel, and finance. The main chapter, which follows, is devoted to divisional reports, and that of the Engineering Division extends to 51 pages. There are sub-sections concerned, for example, with agricultural machinery, aircraft, chemical engineering, iron and steel, and mechanical engineering, and at the end of each of these sections, there are lists of new and revised standards, and particulars of work in hand.

Other chapters are concerned with international activities, and the councils, committees, and officers of the Institution.

Copies of the Report (price 7s. 6d. net) are obtainable from the British Standards Institution, Sales Branch, 2 Park Street, London, W.1.

Coming Events

INCORPORATED PLANT ENGINEERS. *Manchester Branch.* October 14, at 7.15 p.m. at the Engineers' Club, Albert Square, Manchester; paper on "Industrial Electronics," by Commander V. J. Copley-May. *Kent Branch.* October 15, at 7 p.m., at the Kings Head Hotel, High Street, Rochester; paper on "Untrasonics in Industry," by C. B. Abel-Harry.

INSTITUTION OF PRODUCTION ENGINEERS. *Halifax and Huddersfield Section.* October 15, at 7.30 p.m., at the Percival Whitley Technical College, Francis Street, Halifax; lecture on "We Build the Jigmil," by R. C. Fenton. *Birmingham Section.* October 15, at 7.30 p.m., at the James Watt Memorial Institute, Great Charles Street, Birmingham; lecture on "Productivity, the Production Engineer, and the European Common Market," by M. Halls. *Birmingham Graduate Section.* October 14, at 7 p.m., at the James Watt Memorial Institute, Great Charles Street, Birmingham; lecture on "Theory and Practice of Spark Machining," by E. Foster. *Peterborough Section.* October 15, at 7.30 p.m., in the Conference Room, Peterscourt, Peterborough; lecture on "Automatic Linking Devices," by J. B. Jay. *Preston Section.* October 15, at the Harris College of Further Education, Corporation Street, Preston; lecture on "A New Approach to Production Control," by J. L. Burbidge. *Newcastle-upon-Tyne Section.* October 13, at 7 p.m., at the Rutherford College of Technology, Northumberland Road, Newcastle-upon-Tyne; lecture on "Sintered Oxides as Cutting Tools," by H. Eckersley. *London Graduate Section.* October 15, at 7.15 p.m., at the Institution, 10 Chesterfield Street, W.1; lecture on "The Development and Applications of P.T.F.E." by E. M. Elliot. *Western Section.* October 15, at 7.30 p.m., at the Large Lecture Theatre, University of Bristol; lecture on "Productivity in the European Common Market," by Lt.-General Sir Thomas Hutton. *Edinburgh Section.* October 15, at 7.30 p.m., at the North British Hotel, Princes Street, Edinburgh; lecture on "The Mechanical Engineering Research Laboratory—Work of the Mechanisms, Engineering Metrology and Noise Control Division," by C. Timms, D.Eng. (An invitation to attend the meeting is extended to all those interested in research. *Coventry Section.* October 20, at 7.15 p.m., at the Craven Arms, High Street, Coventry; lecture on "Automatically-controlled Machine Tools," by J. A. Stokes, B.Sc.

Transistor Convention

An international convention on transistors and associated semi-conductor devices, planned by the Radio and Telecommunication Section of the Institution of Electrical Engineers, Savoy Place, London, W.C.2, will be held at Earls Court, London, from May 25 to 29, 1959. In conjunction with the convention there will be an international exhibition covering all aspects of transistor and semi-conductor devices. Promoted by the Institution, the exhibition will be arranged by Industrial & Trade Fairs, Ltd., Drury House, Russell Street, London, W.C.2, to whom prospective participants should address enquiries.

Industrial Notes

REFRACTORY MOULDINGS & CASTINGS, LTD., Kegworth, near Derby, inform us that they are moving to larger premises at Market Place, Kegworth.

EUMUCO (ENGLAND), LTD.—The address of this company is now 26 Fitzroy Square, London, W.1 (telephone number, Euston 4651).

UNITED DOMINIONS TRUST, LTD., United Dominions House, Eastcheap, London, E.C.3, have opened a new branch office at 7 Albert Street, Slough, Bucks. (telephone number, Slough 22483/5).

MIDLAND SILICONES, LTD., inform us that their head offices will be moved to larger premises at 68 Knightsbridge, London, S.W.1 (telephone number, Knightsbridge 7801), on October 13.

PHILPOTT & COWLIN, LTD., and the associated company PEE-CEE ENGINEERING SUPPLIES, LTD., recently occupied a new warehouse and offices at 115-119 West Street, Bedminster, Bristol 3 (telephone number, Bristol 61447/8).

SEMINARS ON FORECASTING PROBLEMS IN INDUSTRY, for senior executives, are to be held at the Department of Management Studies, The Polytechnic, Regent Street, London, W.1, and the first will be on October 21 at 3 p.m. Full particulars can be obtained from the above address.

B. ELLIOTT (MACHINERY), LTD., Victoria Works, Willesden, London, N.W.10, inform us that the hydraulic open-side planers previously known as Hydetsco will in future be sold under the name Invicta-Hydetsco as they are now a product of the B. Elliott Group.

AN AUCTION SALE OF MACHINE TOOLS, vehicles, and miscellaneous stores will be held at the Ministry of Supply Storage Depot, Royal Arsenal, Woolwich, London, S.E.18, on October 21, 22, and 23. The auctioneers will be Fuller, Horsey, Sons & Cassell (Dept. N), 10 Lloyd's Avenue, London, E.C.3.

LANCASHIRE DYNAMO NEVELIN, LTD., Oxted, Surrey, report that a 3-phase Varimag variable speed drive has now been developed, and can be supplied for outputs from 3 to 10 h.p. with a speed range of 20 : 1. Previously these drive units were available only for operation on a single-phase A.C. supply, and the output was limited to 2 h.p.

BIM MANAGEMENT SEMINAR PROGRAMME.—The British Institute of Management, 80 Fetter Lane, London, E.C.4, has issued a programme for management seminars to be held during the period starting this month and ending in April, 1959. The seminars which are of one or two days' duration, will be held in Birmingham, Bristol, Glasgow, Leeds, Leicester, London, Manchester, Newcastle, and Sheffield, and will cover many aspects of management.

BROOKHIRST SWITCHGEAR, LTD., Chester, have introduced a watertight version of their type 753 snap action limit switch, for applications which involve complete immersion. This single pole, self re-setting, quick make and break switch may be arranged for operation by push-button or by means of a roller lever. Suitable for A.C. and D.C. control circuits, the switch is rated for 550 volts and 10 amp. A.C.

DEMONSTRATIONS OF A NEWALL TYPE 2436 JIG BORER, incorporating milling equipment, are at present being given at the premises of Optical Measuring Tools, Ltd., Bridge Road, Maidenhead, and will continue until October 18. Arranged by Newall Group Sales, Ltd., Peterborough, the demonstrations cover both toolroom and production work. In addition, O.M.T. optical inspection equipment and rotary indexing tables are on view.

AN EXHIBITION OF GRINDING MACHINES by Wotan, Elb, and Schmaltz will be held by Soag Machine Tools, Ltd., in their London showrooms in Hester Road, Battersea, S.W.11, from October 13 to 17 (10.0 a.m. to 5 p.m. daily). Soag engineers, and representatives from the makers' works. will be in attendance to demonstrate these machines. A number of machines which have been rebuilt by Soag will also be on view, including universal, internal, and surface grinders.

ADAM ENGINEERING CO., LTD., HAESLER SALES DIVISION, 4 Grange Street, St. Albans, Herts., have appointed the following agents for the range of machine tools which they handle in the United Kingdom: McGregor & Moir, 152 London Road, Glasgow, C.1; Mr. F. E. Hoult, The Beeches, Ashover, Derbyshire; Mr. G. B. Shaw, 2 Birmingham Road, Alvechurch, Birmingham; Mr. R. Wiseman, 35 Enville Road, Newport, Mon.; and Mr. F. G. Newman, Chiltern View, 10 Meyrick Avenue Luton, Beds.

CONFERENCE ON SUGGESTIONS SCHEMES.—A week-end conference for the purpose of investigating, in detail, the reasons for the success or failure of suggestions schemes has been organized by the Industrial Welfare Society, Robert Hyde House, 48 Bryanston Square, London, W.1, and will be held at the Grand Hotel, Brighton, from October 31 to November 2. The results of a national survey of suggestions schemes, which was made by the Society's information department, will be discussed and the findings of a group of suggestions schemes secretaries will be examined.

BRITISH VAPOUR BLAST, LTD., Rose Hill, Coalbrookdale, Shropshire.—Building work has now begun on a new factory in Coalport Road, Broseley, near Ironbridge, Shropshire. This step has been necessitated by normal expansion of the business and the growth of demand for large automatic vapour blasting plant for special-purpose applications. The first stage of the new building will comprise two bays, each measuring 120 by 50 ft., and an office block of 134 by 20 ft. Two Tyler units are to be employed for the bays, and it is hoped that they will be completed ready for occupation in November. A separate building, measuring 40 by 15 ft., will house the laboratory

and compressor house. When the new factory has been occupied, the company will close down their premises at Bridgnorth and Coalbrookdale.

THE LINK BETWEEN SCHOOLS AND INDUSTRY will be the subject of a 2-day conference organized by Gloucestershire Industrial Education Council, 8 Lansdown Place, Cheltenham. This conference will be held at Cheltenham Town Hall on October 21 and 22, and speakers on the first and second days will be concerned, respectively, with "what Gloucestershire schools have to offer industry," and "the implications of new technological developments." Applications for tickets should be sent to the Council Secretary, Mr. G. T. Page, at the above address.

There will be a conversazione on the evening of October 21, and an exhibition with the theme "opportunities in engineering," will be held, in conjunction with the conference in Imperial Gardens, Cheltenham, from October 21 to 25. The general public will be welcome and visits by parties of schoolboys and schoolgirls will be arranged.

Safety in Die Casting

(*Continued from page* 803)

they have failed to open fully to admit the strut.

Largely as a result of valuable work which has been undertaken by certain die casters and firms specializing in the production and supply of guards, various possibilities of faulty functioning or operation, on machines of different types, have been successively tackled. Based on these investigations, some highly developed guards have been introduced which afford a very satisfactory degree of safety combined with minimum interference with production. For example, one such guard is arranged for rapid power closing, but will retract without causing injury if it should make contact with the operators arm or body. When the guard is closed, it is automatically locked in position, and after it has been locked, the die closing valve is automatically opened. The machine then completes its automatic cycle, and after the dies have opened, the guard is unlocked and automatically withdrawn.

When really effective guards are widely employed it is evident that risk of injury in die casting shops will be greatly reduced. At the same time, the assurance thus afforded to operators will frequently results in higher outputs. In the meanwhile it is recommended that simpler guards should be provided, where necessary, to give reasonable protection.

Sir Alfred Herbert Paper

The subject of the 1958 Sir Alfred Herbert Paper to the Institution of Production Engineers will be "The European Common Market—Its Origins and Implications." This paper will be presented at the Royal Institution, Albemarle Street, W.1, on December 11, at 6.30 p.m., by Sir Cecil Weir, K.C.M.G., K.B.E., M.C., D.L., a past-president of the Institution, chairman of the British Tabulating Machine Co., Ltd., and former head of the U.K. Delegation to the High Authority of the European Coal and Steel Community. The chair will be taken by the Rt. Hon. The Earl of Halsbury, F.R.I.C., F.Inst.P., M.I.Prod.E., president of the Institution. This meeting will be open to both members and non-members. Admission will be by ticket only, and those wishing to attend are advised to make early application to The Secretary, Institution of Production Engineers, 10 Chesterfield Street, London, W.1.

Obituary

MR. HOWARD CLAYTON-WRIGHT, chairman and founder of Howard Clayton-Wright, Ltd., Wellesbourne, Warwick, died on September 26 after a short illness.

MR. F. A. SPENCE-BROWN, a joint managing director of Johnson, Matthey & Co., Ltd., 73-83 Hatton Garden, London, E.C.1, died suddenly on September 29.

Correction

In MACHINERY, 93/793—1/10/58, it was incorrectly stated that Mr. J. Higginbotham and Mr. J. D. Studholme had been appointed deputy general manager and assistant general manager, respectively, of Edgar Allen & Co., Ltd., Imperial Steel Works, Sheffield, 9. These appointments relate to the Engineering Department only and not to the company as a whole.

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8/10/58

Personal

MR. ROBERT E. KAAN, Dipl. Ing., has been appointed export sales manager for S. N. Bridges & Co., Ltd., York Road, Battersea, London, S.W.11. He was previously export executive of B.E.A.M.A.

MR. C. A. HENDERSON has been appointed general manager of Eutectic Welding Alloys Co., Ltd., North Feltham Trading Estate, Faggs Road, Feltham, Middlesex. He obtained his early technical training in Manchester, and has since been employed by Metropolitan-Vickers Electrical Co., Ltd.

MR. H. MCPHIE, B.Sc., A.R.C.S.T., M.I.Mech.E., M.B.I.M., has recently been appointed administration controller to Charles Churchill & Co., Ltd., Coventry Road, South Yardley, Birmingham. He was formerly industrial engineer with British Insulated Callender's Cables, Ltd., and has had considerable experience in the fields of work study, and co-ordinated commercial, production and costing procedures.

Machine Tool Share Market

After some irregularity, a strong tone developed in the principal sections of the stock market, and the period under review closed on a cheerful note, with activity at a high level.

The outstanding feature was the firmness of the market for British Funds and similar gilt-edged issues, quotations for which advanced steadily, and finished at the highest levels.

Industrial share markets after being quiet and irregular became steady to firm, and numerous rises in prices were recorded, as a result of sustained investment buying.

Among machine tool issues, Edgar Allen advanced 1s. 3d. to 34s. 3d.; Asquith Machine Tool, 9d. to 21s. 3d.; British Oxygen, 1s. to 40s.; John Holroyd, "A," 1s. to 13s.; John Holroyd "B," 1s. to 12s. 6d.; Churchill Machine Tool, 6d. to 17s. 3d.; Craven Bros. (Manchester), 6d. to 7s. 7½d.; Ambrose Shardlow, 6d. to 43s. 6d.; Tap & Die Corporation, 6d. to 8s.; Broom & Wade, 9d. to 13s. 3d.; B. & S. Massey, 9d. to 9s.; Stedall & Co., 9d. to 7s. 6d.; Butler Machine Tool, 3d. to 8d.; Sheffield Twist Drill, 3d. to 12s.; Chas. Churchill, 1½d. to 5s. 1½d.; and Wadkin, Ltd., 1s. 3d. to 18s. 9d.

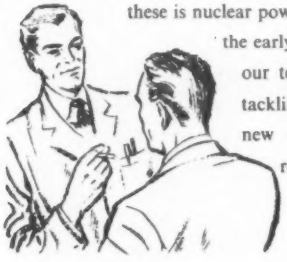
STEDALL & CO., LTD.—Interim dividend 5 per cent (same)

COMPANY		Denom.	Middle Price
Abwood Machine Tools, Ltd.	Ord.	1/-	9d.
Armstrongs, Stevens & Son, Ltd.	Ord.	5/-	8/3
Allen (Edgar) & Co., Ltd.	Ord.	£1	34/3
" "	5% Prf.	£1	15/3*xd
Arnott & Harrison, Ltd.	Ord.	4/-	15/-
Asquith Machine Tools Corp., Ltd.	Ord.	5/-	21/3
" " "	6% Cum. Prf.	£1	18/6
Birmingham Small Arms Co., Ltd.	Ord.	£1	31/9
" " "	5% Cum. "A" Prf.	£1	15/6
" " "	6% Cum. "B" Prf.	£1	18/-xd
" " "	4% 1st Mort. Deb.	Stk.	88½
British Oxygen Co., Ltd.	Ord.	£1	40/-
" " "	6½% Cum. Prf.	£1	22/-
Brooke Tool Manufacturing Co., Ltd.	Ord.	5/-	3/10½
Broom & Wade, Ltd.	Ord.	5/-	13/3
" "	6% Cum. Prf.	£1	17/9xd
Brown (David) Corporation Ltd.	5½% Cum. Prf.	£1	14/-
Buck & Hickman, Ltd.	6% Cum. Prf.	£1	17/9
Butler Machine Tools Co., Ltd.	Ord.	5/-	8/-
" "	5% Cum. Prf.	£1	13/9
C.V.A. Jigs, Moulds & Tools, Ltd.	5½% Red. Cum. Prf.	£1	11/3
Churchill (Charles) & Co., Ltd.	Ord.	2/-	5/1½
" " "	6% Cum. Prf.	£1	26/10½
Churchill Machine Tool Co., Ltd.	Ord.	5/-	17/3
" " "	6% Cum. Prf.	£1	18/3
Clarkson (Engrs.), Ltd.	Ord.	5/-	15/-xd
Cohen (George), Son & Co., Ltd.	Ord.	5/-	10/9
" " "	4½% Cum. Prf.	£1	14/6
Coventry Gauge & Tool Co., Ltd.	Ord.	10/-	16/1½
" " "	5% Cum. Red. Prf.	£1	16/3
Coventry Machine Tool Works, Ltd.	Ord.	4/-	8/6
Craven Bros. (Manchester), Ltd.	Ord.	5/-	7/7½
Elliott (B.) & Co., Ltd.	Ord.	1/-	3/3xd
" "	4½% Red. Cum. Prf.	£1	13/9
Expert Tool & Case Hardening Co., Ltd.	Ord.	2/-	1/3
Firth Brown Tools, Ltd.	4% Cum. Prf.	£1	12/6
Greenwood & Batley, Ltd.	Ord.	£1	50/7½
Harper (John) & Co., Ltd.	Ord.	5/-	15/7½
" "	4½% Red. Cum. Prf.	£1	12/10½
Herbert (Alfred), Ltd.	Ord.	£1	35/7½
Holroyd (John) & Co., Ltd.	"A" Ord.	5/-	13/-
" "	"B" Ord.	5/-	12/6
Jones (A. A.) & Shipman, Ltd.	Ord.	5/-	23/-
" " "	7% Cum. Prf.	5/-	5/-
Kayser, Ellison & Co., Ltd.	Ord.	£1	44/-
" " "	6% Cum. Prf.	£1	18/3
Kendall & Gent, Ltd.	Ord.	5/-	7/-
Kerry's (Gt. Britain), Ltd.	Ord.	5/-	6/3
Kitchen & Wade, Ltd.	Ord.	4/-	8/3
Martin Bros. (Machinery), Ltd.	Ord.	2/-	2/4½
Massey, B. & S., Ltd.	Ord.	5/-	9/-
Modern Engineering Machine Tools Ltd.	Ord.	5/-	10/7½
Newall Engineering Co., Ltd.	Ord.	2/-	4/9
Newman Industries, Ltd.	Ord.	2/-	2/3
" "	6% Prf. Ord.	5/-	5/6
Noble & Lund, Ltd.	Ord.	2/-	3/9
Osborn (Samuel) & Co., Ltd.	Ord.	5/-	21/-
" " "	5½% Cum. Prf.	£1	25/6xd
Pratt (F.) & Co., Ltd.	Ord.	5/-	21/3
Scottish Machine Tool Corporation, Ltd.	Ord.	4/-	5/6
Shardlow (Ambrose) & Co., Ltd.	Ord.	£1	43/6
Shaw (John) & Sons, Wolverhampton, Ltd.	Ord.	5/-	13/1½
Sheffield Twist Drill & Steel Co., Ltd.	Ord.	4/-	12/-
" " "	5% Cum. Prf.	£1	15/-
Stedall & Co., Ltd.	Ord.	5/-	7/6
	"B" non-voting Ord.	10/-	20/-
Sykes (W. E.) Ltd.	Ord.	5/-	8/-
Tap & Die Corporation, Ltd.	4½% Deb. 1961-1977	Stk.	82/-
" " "	Ord.	10/-	18/9
Wadkin, Ltd.	Ord.	£1	83/6
Ward (Thos.) W.), Ltd.	5% Cum. 1st Prf.	£1	16/-
" "	5% Cum. 2nd Prf.	£1	24/-
" "	Ord.	1/-	2/4½
Willson Lathes, Ltd.			

The Middle Prices given in the list are in several cases nominal prices only and not actual dealing prices. Every effort is made to ensure accuracy, but no liability can be accepted for any error. * Sheffield price. † Birmingham price.

Have Ransome and Marles been associated with any of the big developments in British industry?

We don't hit the headlines — but we often help to make headline news possible. Since the war we have carried out research into design, materials, lubrication and production for a number of important projects. One of these is nuclear power generation. From the early days of Calder Hall our technicians have been tackling fresh problems as new and more powerful reactors are designed.



Are there any other interesting projects?

Yes, several. Britain has been achieving a world-wide success with her aircraft engines. Two notable users of R&M Bearings are Armstrong-Siddeley Motors and Bristol Aero Engines. The Proteus engines of the latest Bristol Britannia are of course fitted with R&M Bearings.

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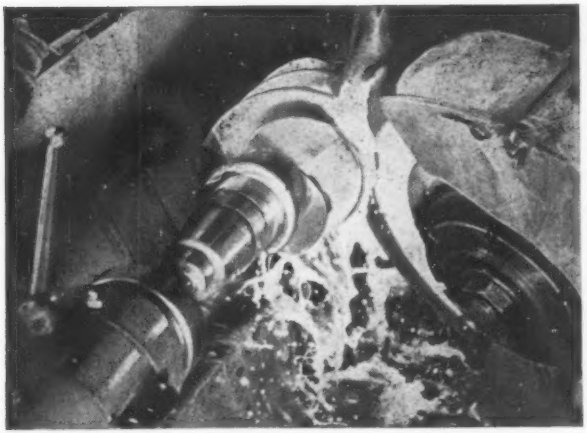

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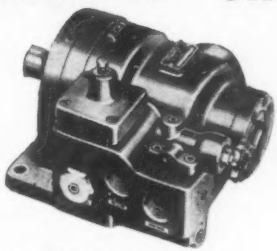
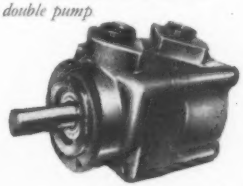


Series VC-138 Combination double pump.



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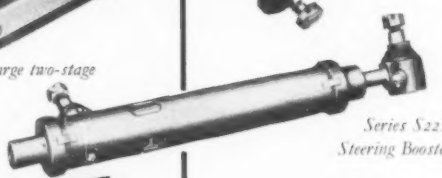

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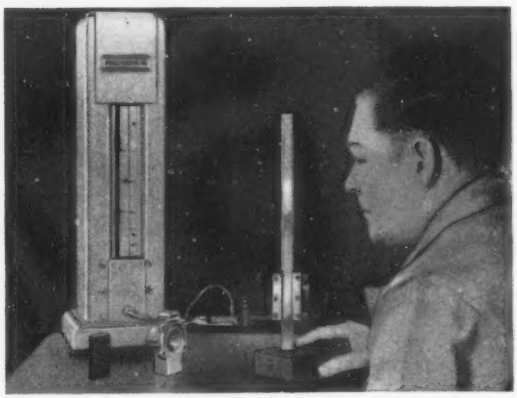

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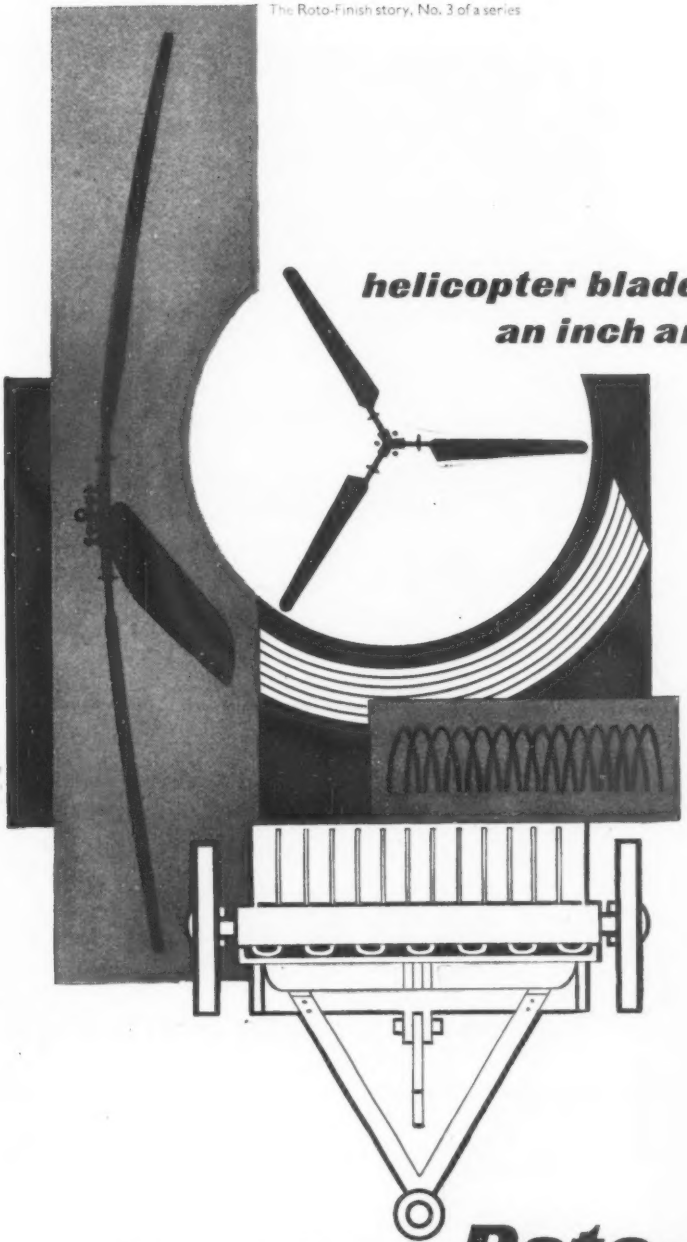

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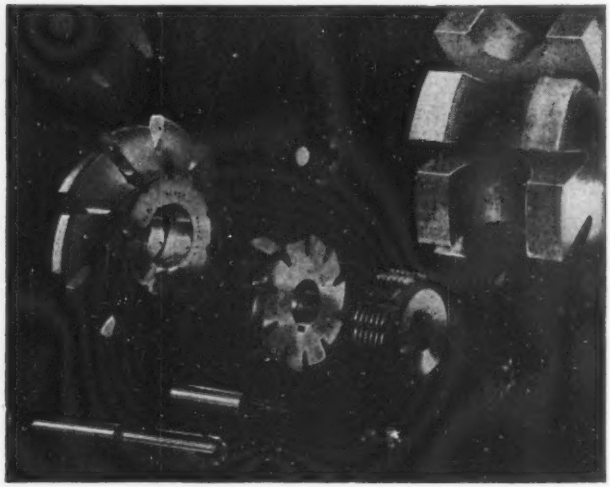

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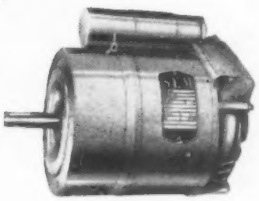

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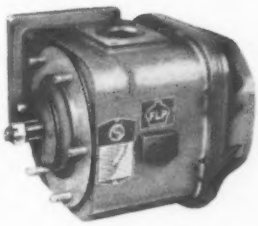

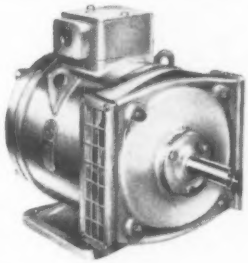

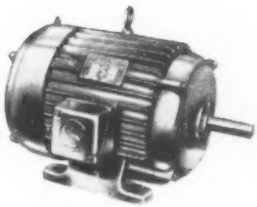

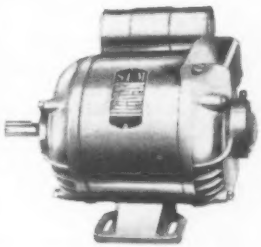

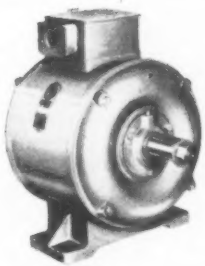

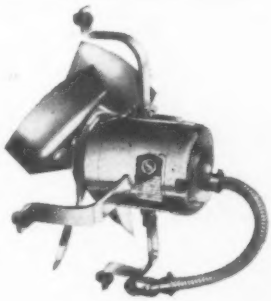

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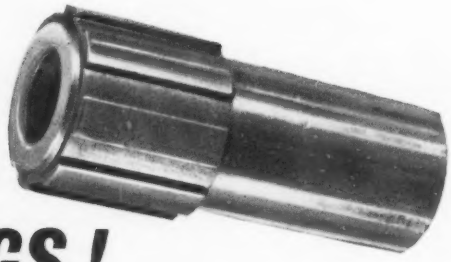

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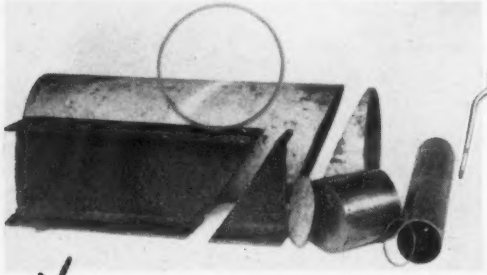

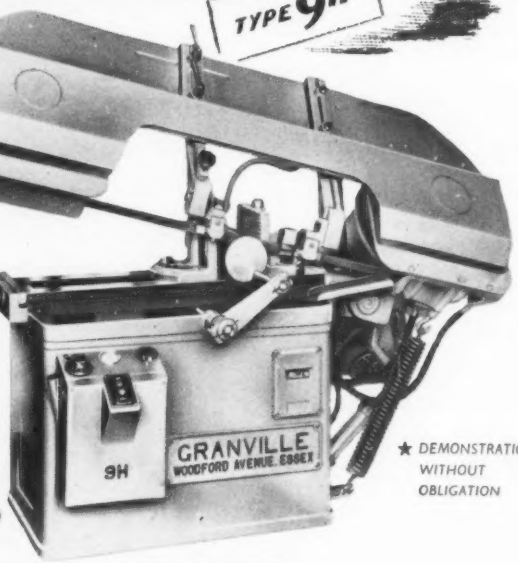

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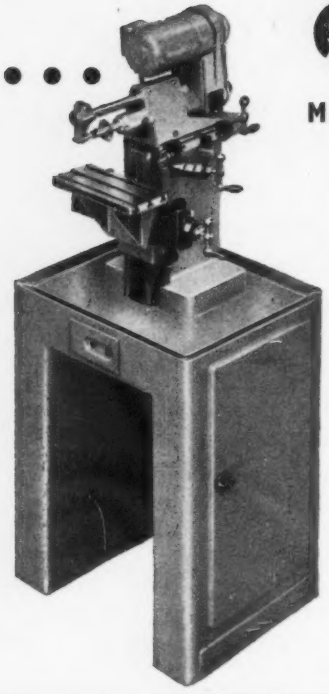

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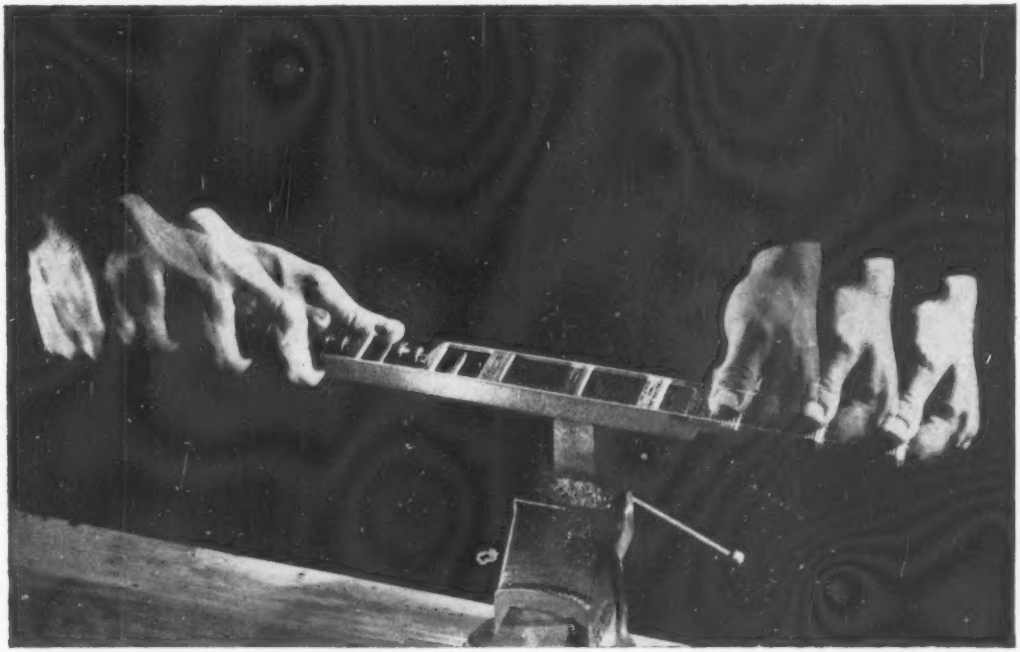

Sheffield Test Report No. 87760: A SURFORM Standard Blade was tested on a piece of copper, 1" square, under a 24 lb. load and using a stroke length of 6". At the end of thirty minutes, 1·04" of the copper had been removed with 1,530 strokes of the SURFORM blade.
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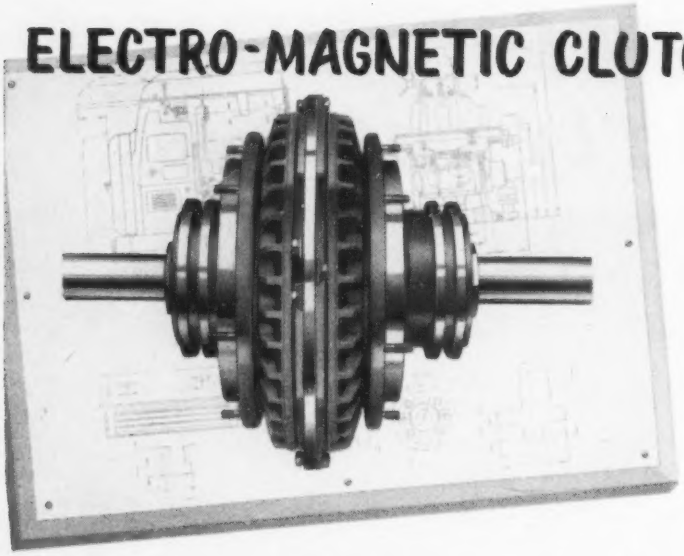

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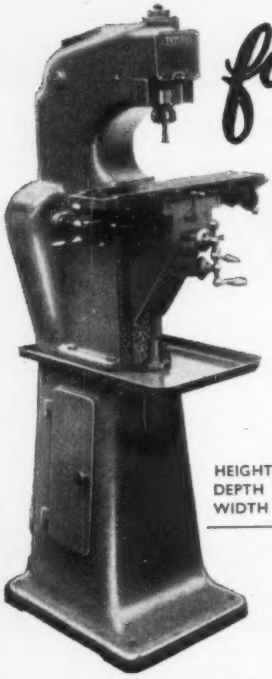

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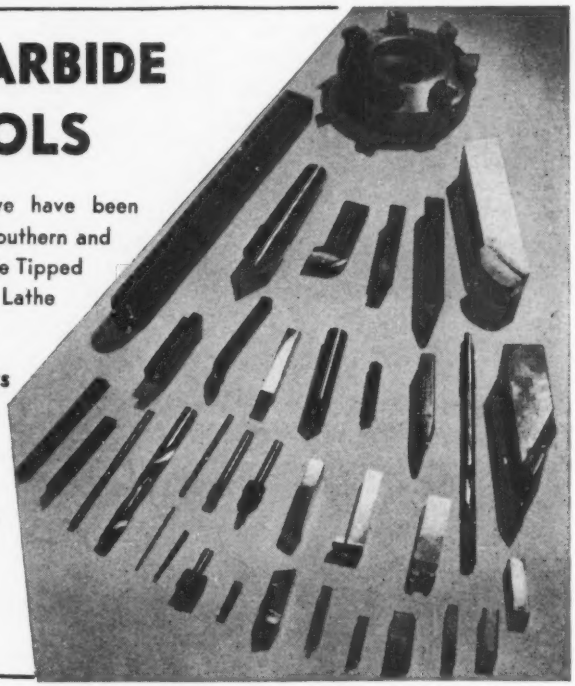

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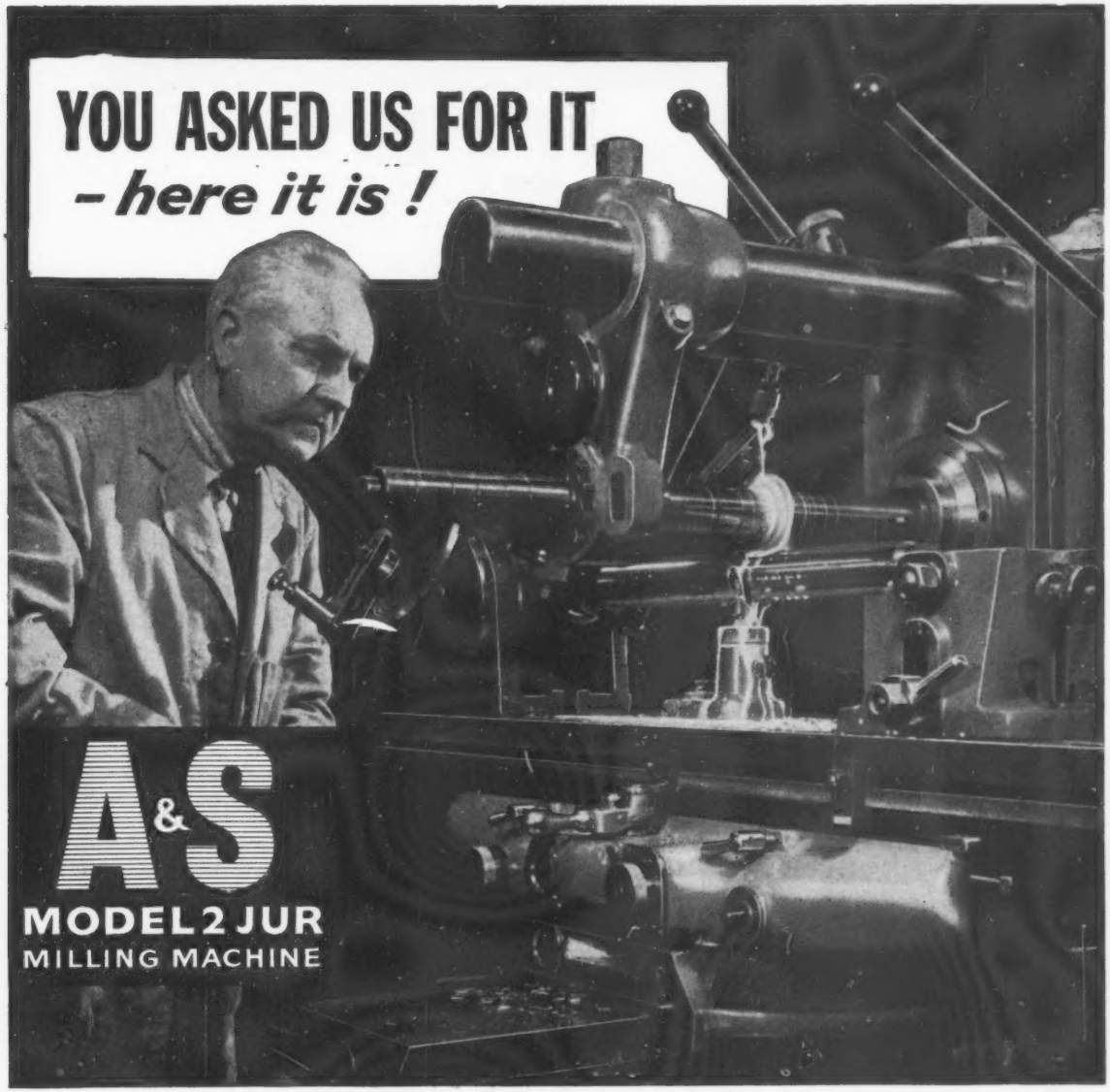

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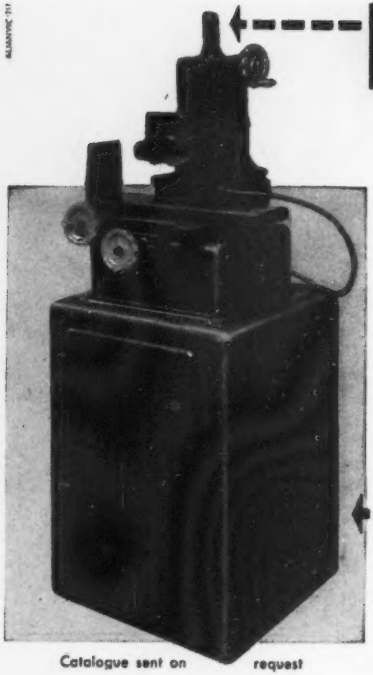

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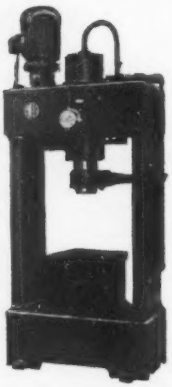

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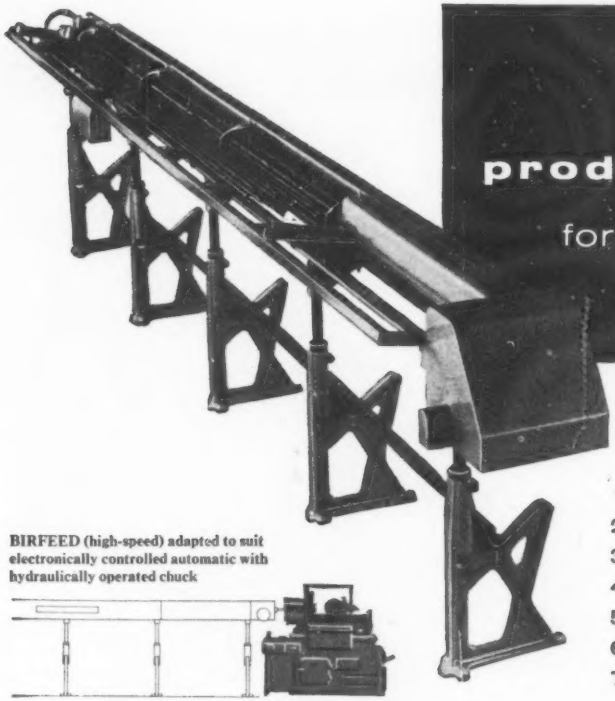

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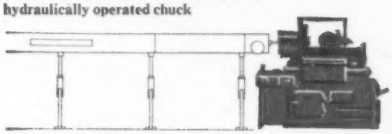
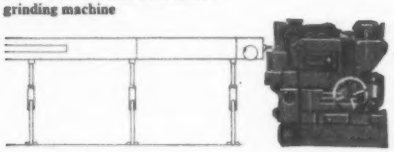
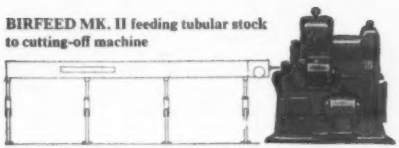


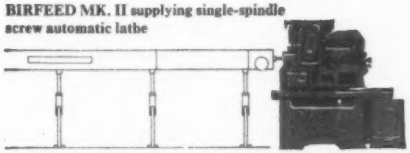
BIRFEED attached to centreless grinding machine



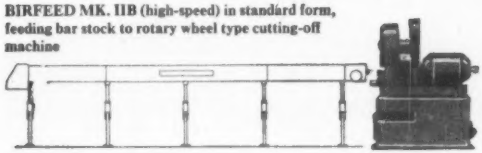
BIRFEED MK. II feeding tubular stock to cutting-off machine



BIRFEED MK. II supplying single-spindle screw automatic lathe



BIRFEED MK. IIB (high-speed) in standard form, feeding bar stock to rotary wheel type cutting-off machine



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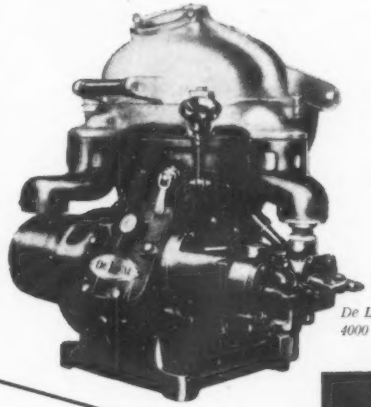

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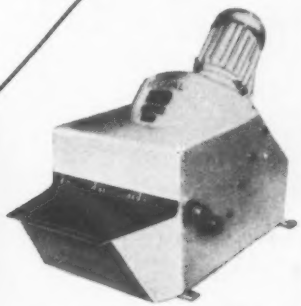

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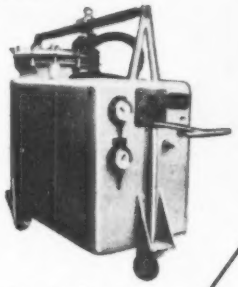

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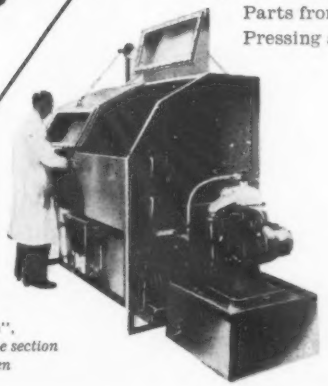
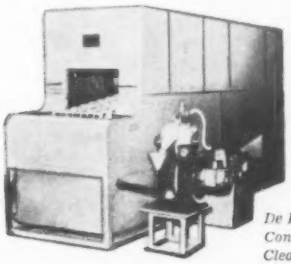


Type 'R' "Parawash", showing one section of hood open



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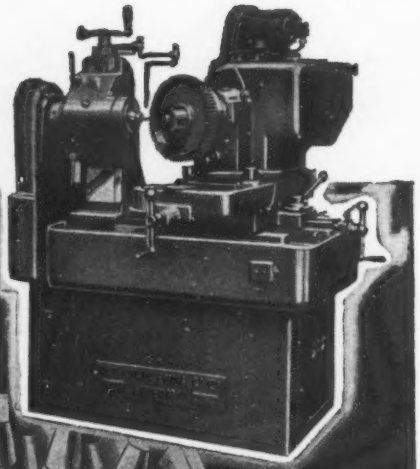

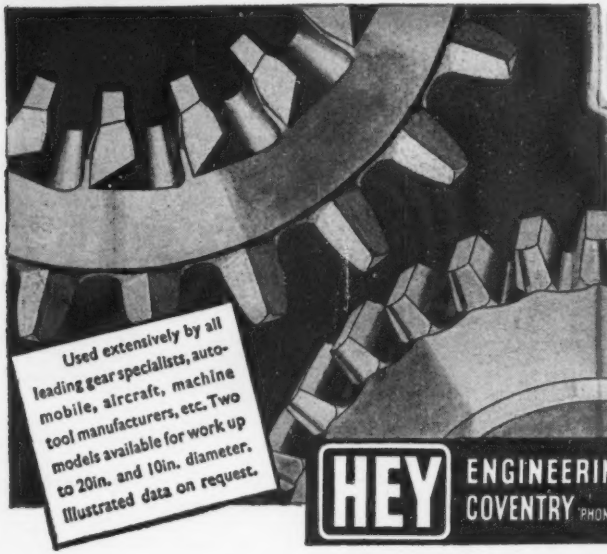

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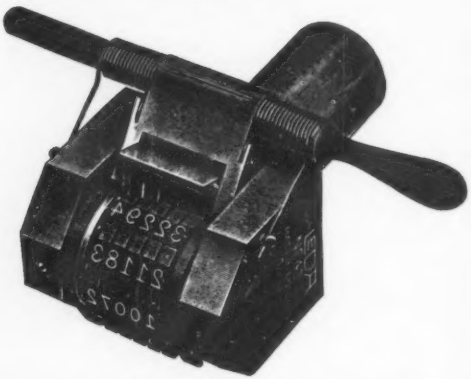

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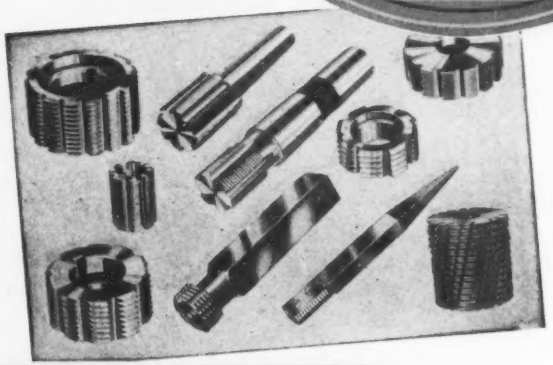

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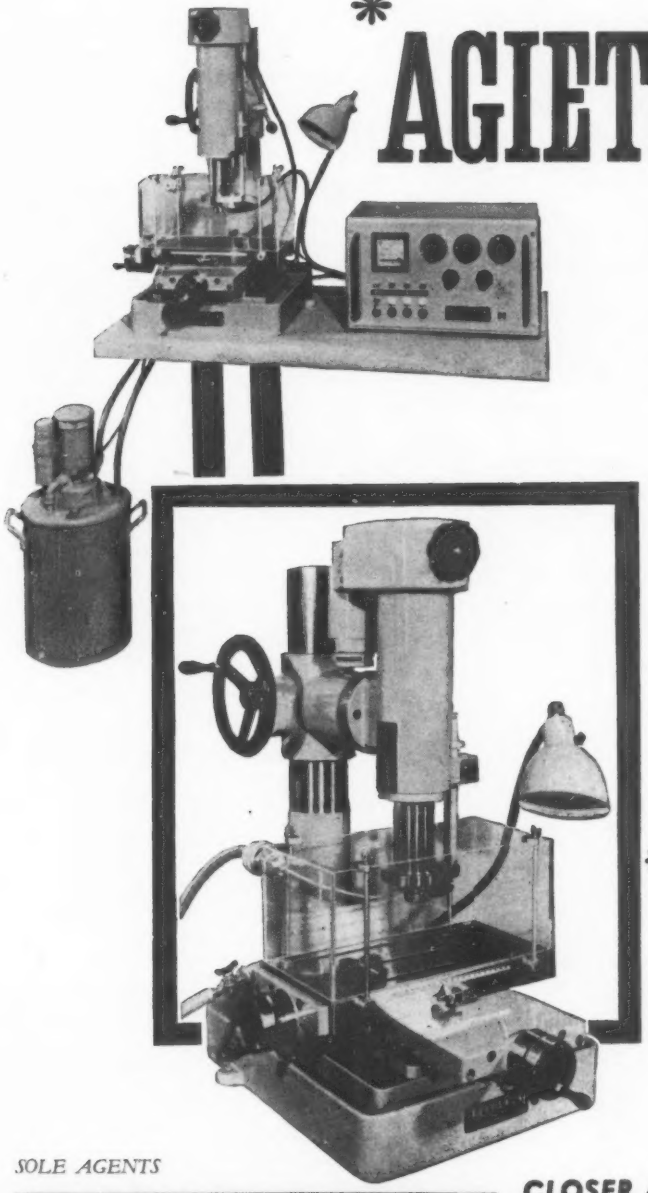

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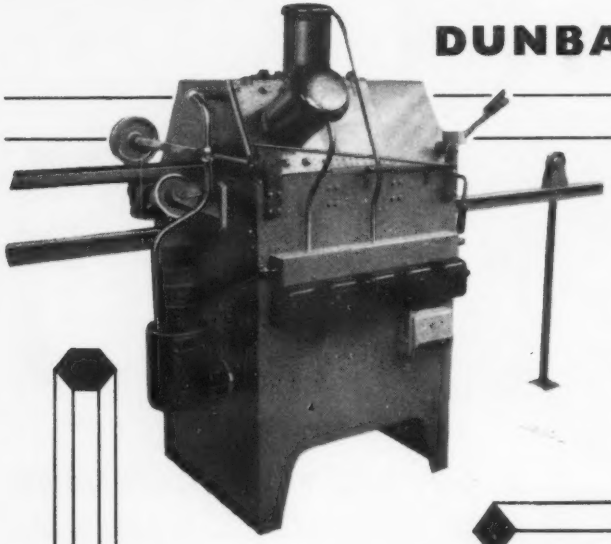

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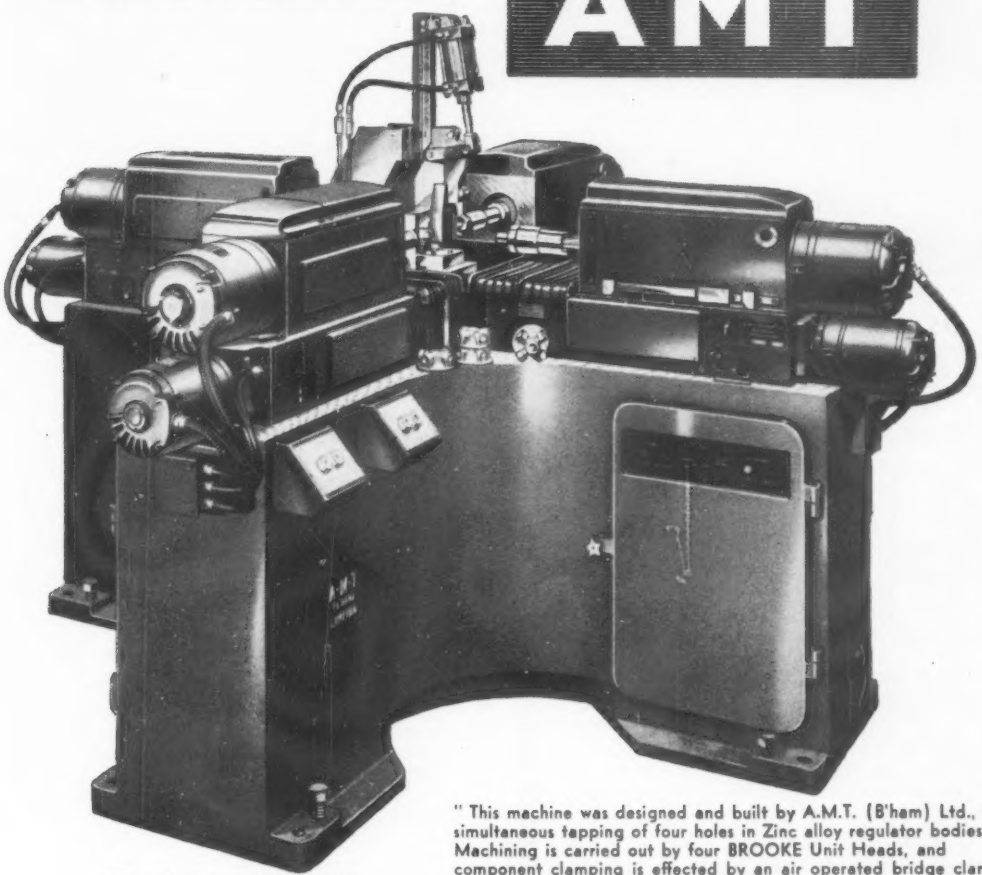

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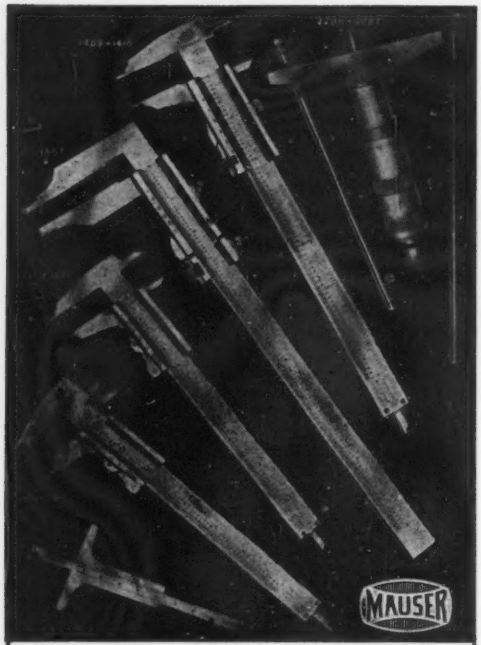

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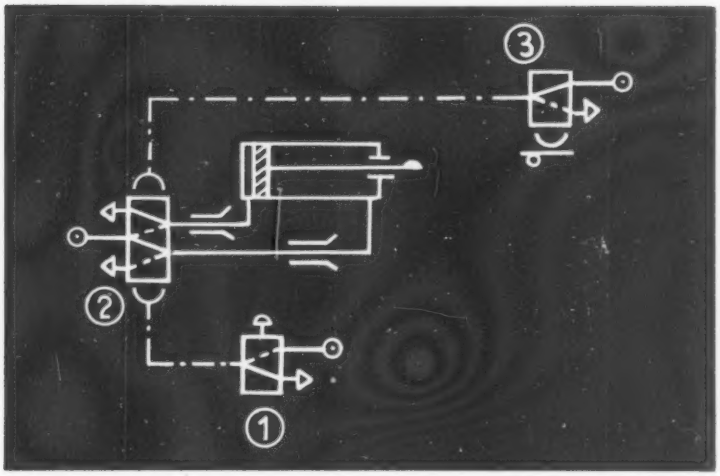

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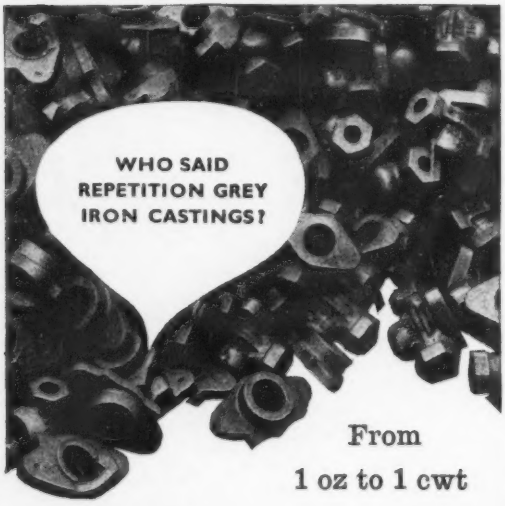

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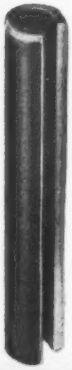

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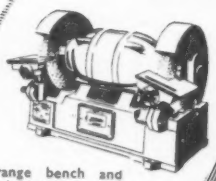

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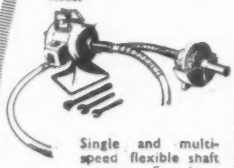

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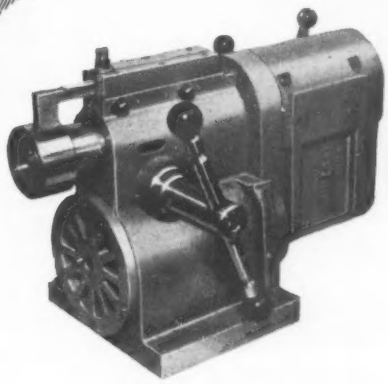

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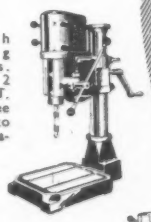

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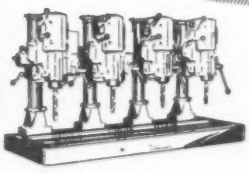

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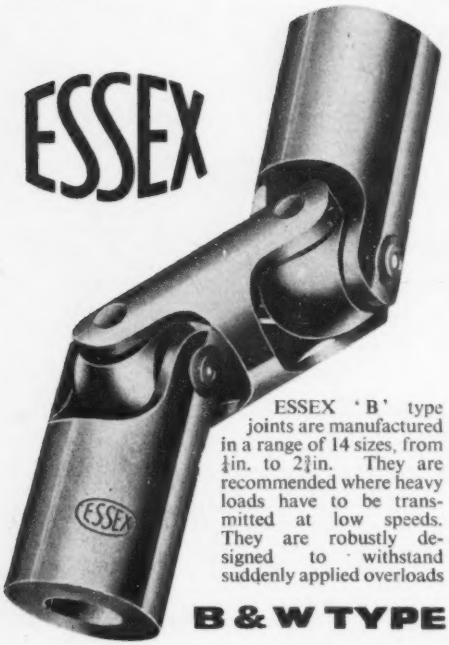

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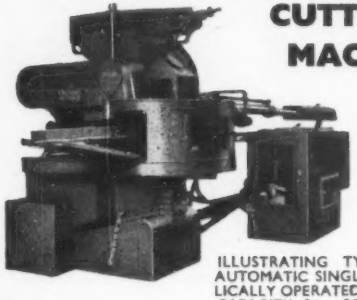

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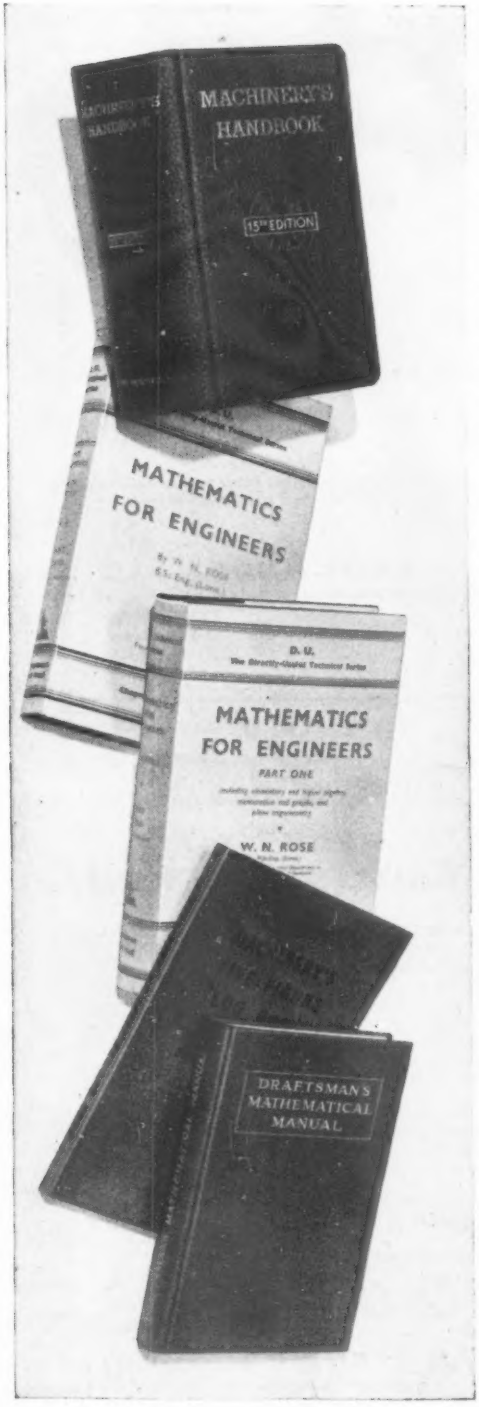

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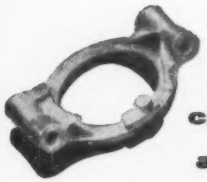

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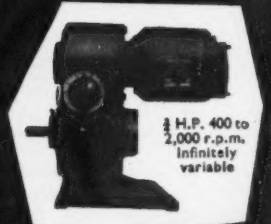

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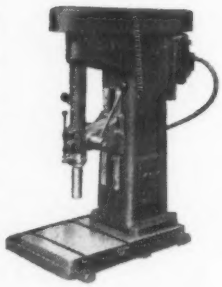

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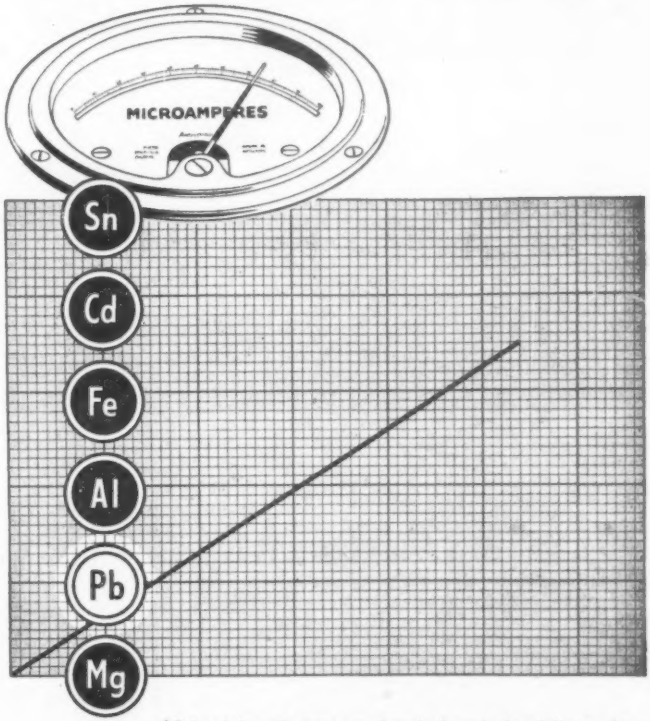

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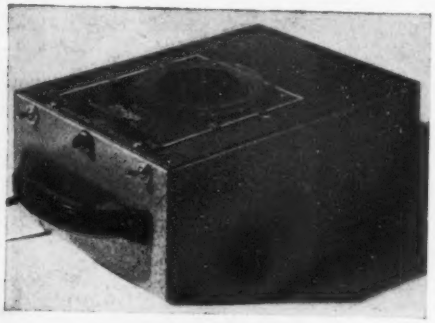

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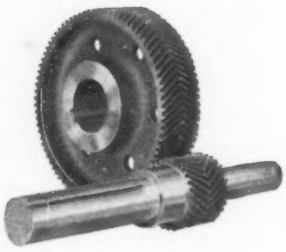

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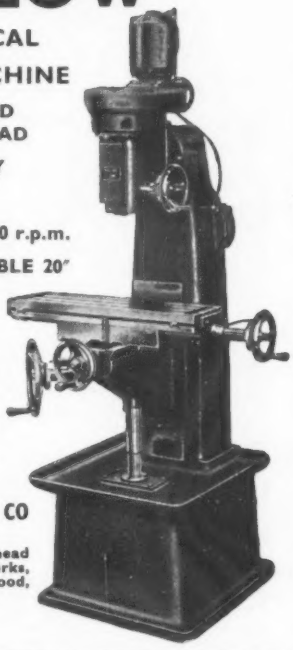

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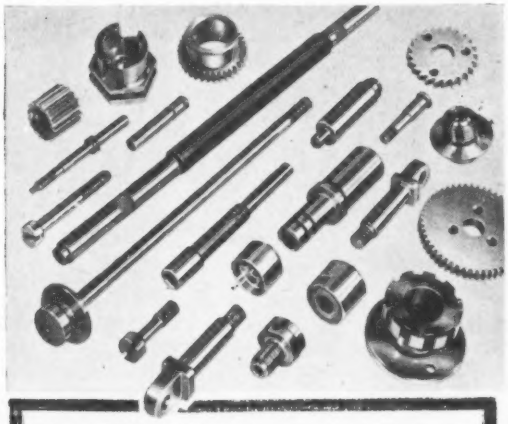

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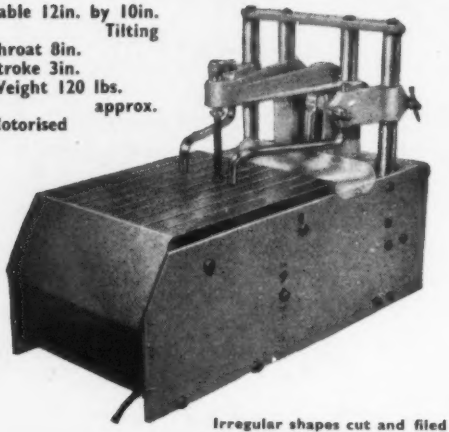

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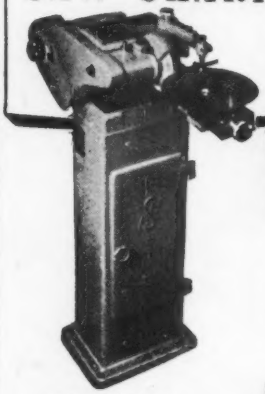

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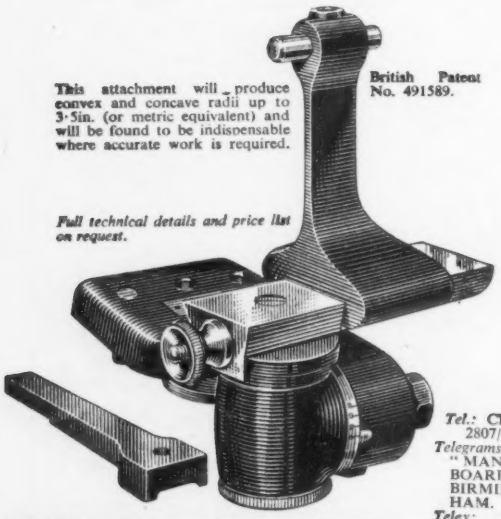

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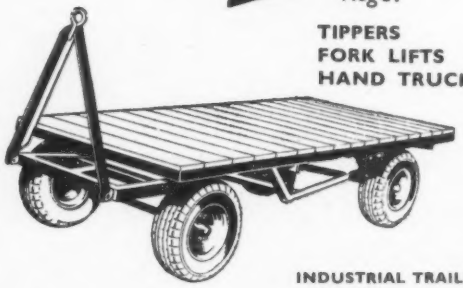

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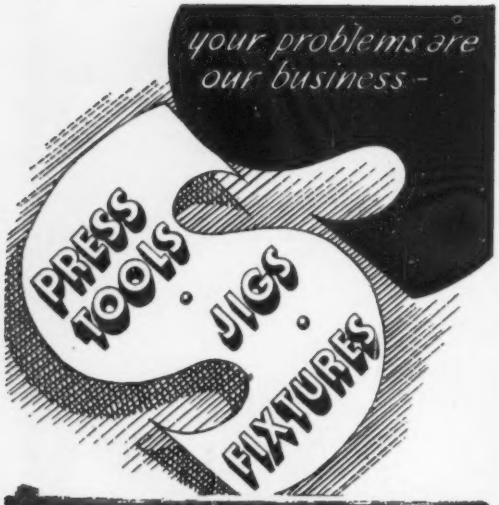

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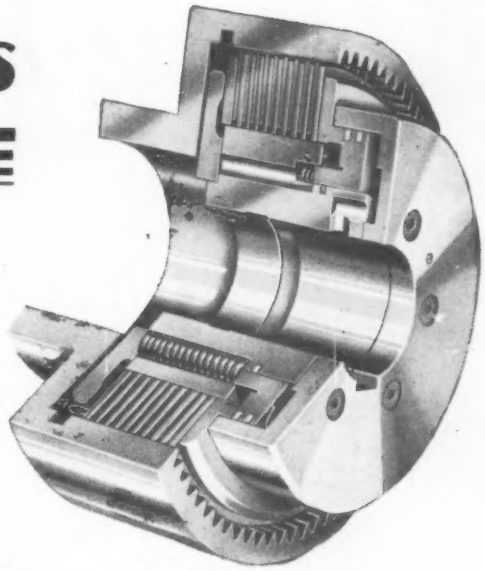

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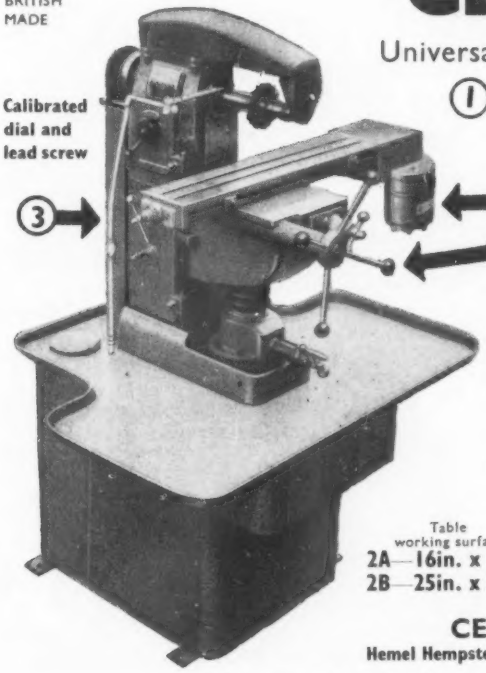

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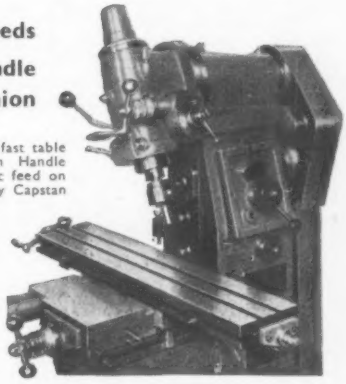

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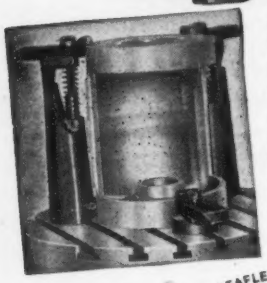

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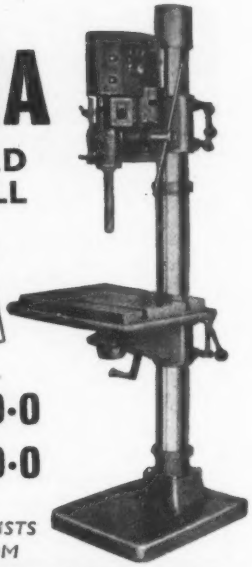

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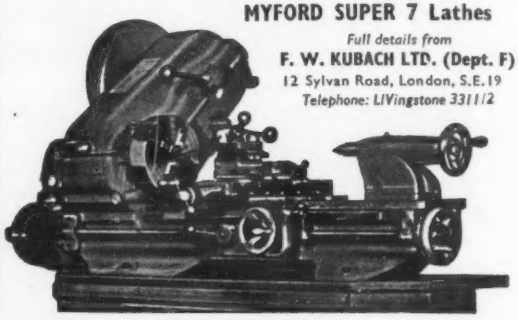

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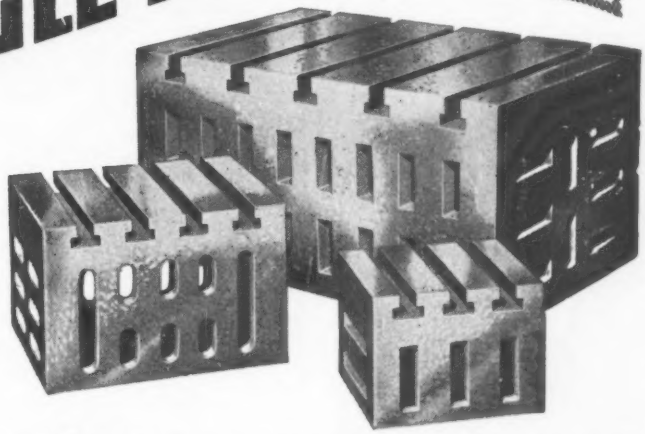

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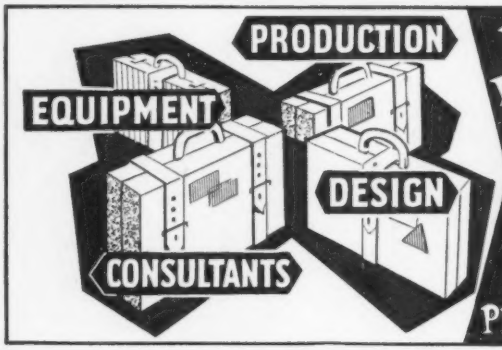

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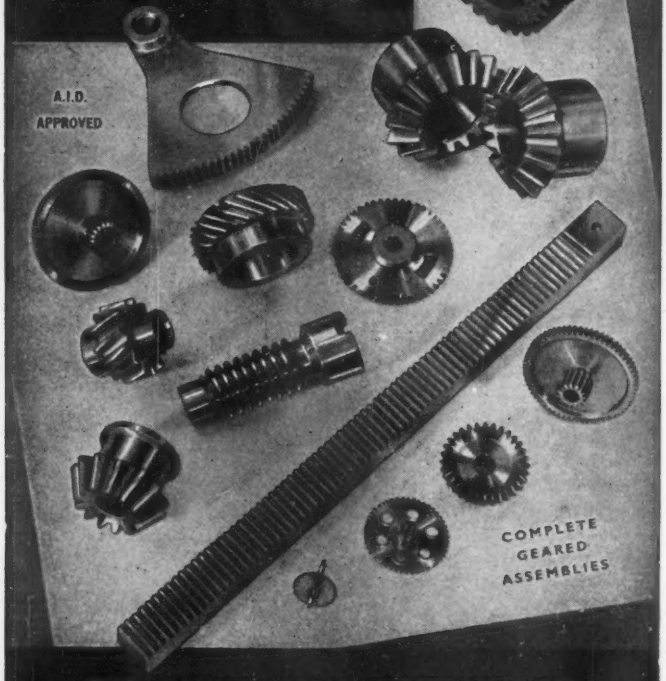

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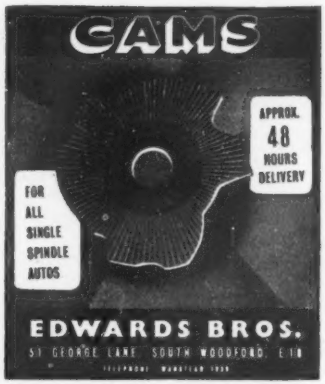

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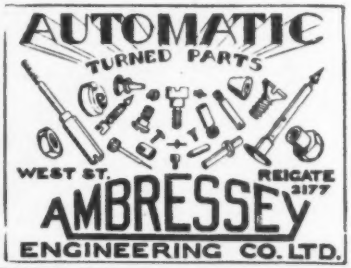

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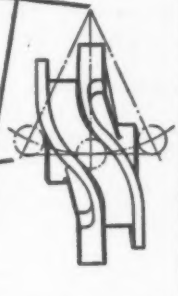

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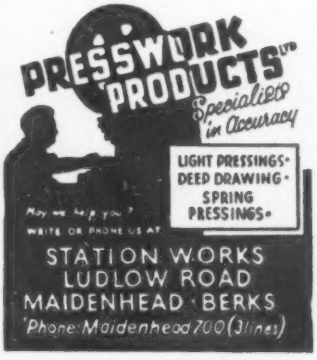

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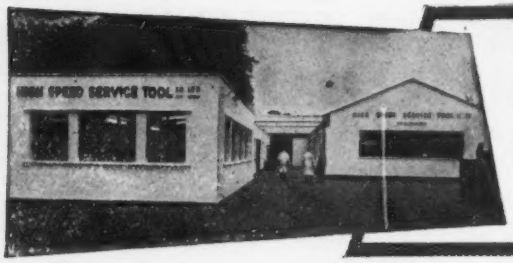

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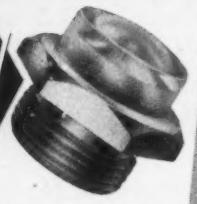

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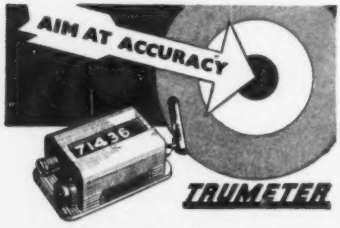

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REED PRENTICE No. 6 Vertical Milling Machine, table 84in. by 20in.
CINCINNATI 1/12 Horizontal Production Milling Machine.
CENTEC Model 3R Automatic Production Milling Machine, table 8in. by 2in.
CINCINNATI 2M Universal Milling Machine.

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URQUHART LINDSAY & ROBERTSON ORCHAR Spiral Drive Heavy Duty Planing Machine, capacity 16ft. by 5ft. by 5ft.
FRORIEP Planing Machine, 13ft. stroke by 3ft. 6in. with Lancashire Dynamo drive.

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ARCHDALE 28in. Heavy Duty Pillar Drilling Machine, No. 5 Morse Taper Spindle.
T.M.A. G2 Engraving Machine with Cutter Grinder. Etching Unit.
SYKES HV14 Universal Hobbing Machine, capacity 14in. dia., 9in. face, 6 d.p.
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DENHAM 15in. Centres All-geared Gap Bed S.S. & S.C. Lathe, swing 50in. in gap, 6ft. 6in. between centres.
CHURCHILL-REDMAN 9in. Centres All-geared Gap Bed S.S. & S.C. Lathe, admit 54in. between centres.
ALFRED HERBERT No. 7 Junior Combination Turret Lathe, Flamard Bed.
WARD No. 3A Bar Feed Capstan Lathe, high speed range auto feed, cross slide.
CHURCHILL-REDMAN 24ND Turret Type Boring and Surfacing Lathe, 24in. swing.
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ACME 5W Universal Turret, 2in. Bar feed.
LIBBY 4A, 2in. Bar feed.
MURAD ⅜in. Bar feed.
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T.M.A. Type G.3 and G.2.
LIENHARD Type 3R and 2.
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RAPIDOR No. 1 Hacksaw.
WICKSTEED Cold Saw No. 1, 6in.

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JONES & SHIPMAN 310. T. & C.
J. & S. 12in. × 24in. 305 T. & C.
EXCEL T. & C.
JONES & SHIPMAN Carbide.
HERBERT HUNT No. 4 Drill.

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JONES & SHIPMAN 540 18 × 6 cap.
SNOW Table, 20in.
CHURCHILL OSB, 40in. × 18in.
WRIGHT 8in. Table.
ROBOT 18 × 6.
SNOW P24, 24in. × 8in. Hyd.
ABWOOD 18 × 6 Vertical.

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SAACKE Model VJ1, Jig.

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KEMPSMITH No. 1G and 2G.
BROWN & SHARPE No. 12 and 000 prod.
CINCINNATI 08 and 1-18 Prod.
BROWN & SHARPE No. 2 Univ. Light.
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BURKE. Table 16 × 3¾.
ARCHDALE 28in. Mfr. and G.P.
CINCINNATI 3-24 Hyd. and 2 M.H.
HERBERT 1S. Table 18in. × 8½in.

MILLERS (Vertical)
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CLEVELAND No. 1. Table 22 × 8.
RICHMOND VHM. Table 26 × 8.
VICTORIA V2. Table 40 × 10.
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BESCO TVO Bench, 4 ton.
O. & S. 30 tons straightening.
BESCO EB4, 40 tons. New.
TAYLOR & CHALLEN B2, 10 tons.
RHODES No. 19. 10 ton.
SCHULER VZZ, 15 tons d/s gripper feed.

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ROTORIVET No. 5 Hammer.
TURNER RH 14/12.

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JONES No. 26. 2 B.A.-⅜in.
THIEL Nos. 3 and 4.
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REINECKER 8 × 72in.
LEES BRADNER Mod. 40. 6½in. H.M.
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Cincinnati Duplex Hydromatic Miller, 4/48 Model, 1948 machine.—BOX Z511, MACHINERY, Clifton House, Euston Road, N.W.1.

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WICKMAN Auto., cap. 10mm., motorised.
WARD 2A. A.G.H., bar feed, motorised.
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BOLEY & LEINEN Precision Capstan. Model S.R.26. Collet cap. 1in., mot. 415/3/50.

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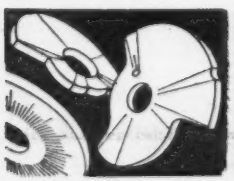

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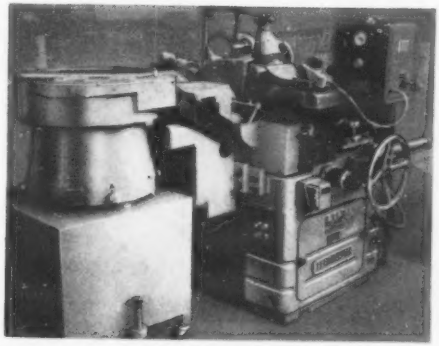
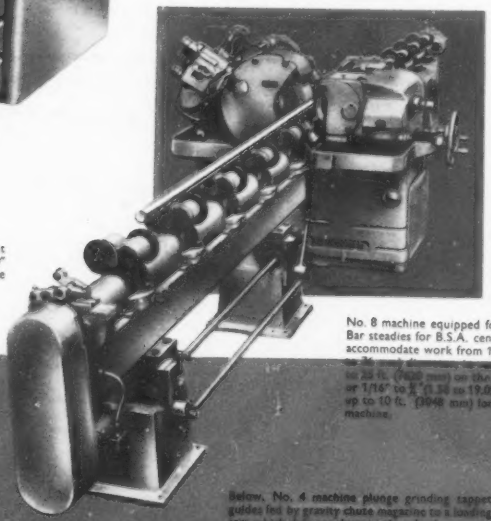


No. 4 machine equipped for automatic sizing-control and automatic infeed. Vibratory type hopper. Special bolts 7/16" × 2⅞" (11 mm × 73 mm) long are ground to a tolerance of 0.0005" (0.012 mm). Production: 700 bolts per hour. Sizing-control incorporates automatic grinding wheel head feed-compensation.

No. 4 MACHINE

Work diameter:	1/16" to 3"* (1.58 to 76 mm)
Grinding wheel Speed:	1270 rpm
Control wheel Speeds:	4
Width of wheels	4" (101 mm) or 5" (127 mm)
Main motor:	10 h.p.

*(With special equipment work down to 0.010" (0.254 mm) dia. can be accommodated).

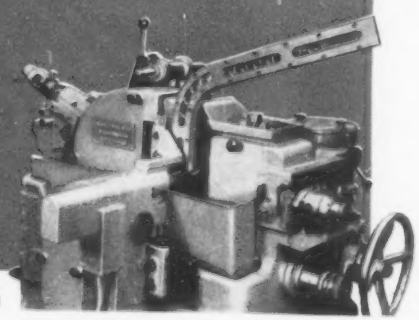


No. 8 machine equipped for bar grinding. Bar steadies for B.S.A. centreless grinders accommodate work from 1/16" to 3" (1.58 to 76 mm) diameter, in lengths up to 20 ft. (6096 mm) on the No. 8 machine, or 1/16" to 2" (1.58 to 19.05 mm) diameter up to 10 ft. (3048 mm) long on the No. 4 machine.

No. 8 MACHINE

Work diameter:	⅛" to 6½" (3.17 to 167 mm)
Grinding Wheel Speed:	1160 rpm
Control Wheel Speeds:	12
Width of Wheels:	5" (127 mm) or 8" (203 mm)
Main Motor:	20 or 40 h.p.

Below, No. 4 machine plunge grinding tapper guides fed by gravity chute magazine to a loading ram which delivers them to the wheels.



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